AVIATION WEEK

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AUGUST 17, 1953

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AVIATION WEEK

August 17, 1953
Volume 59 Number 7

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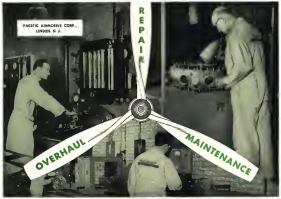

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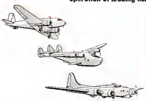
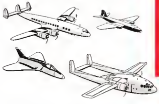


Since the earlier days of the DC-1, the Yankee Clipper and the B-17, Barber-Colman controls have been on most of America's history making planes.

Today, on more and more aircraft, such as the Super Constellation, B-57, F4D, C-119 and many others, Barber-Colman controls contribute to better performance.



These key aircraft manufacturers are among the many who have helped greatly in the constant development and refinement of Barber-Colman controls: Boeing; Beech; Canadair; Consolidated Vultee; Chance-Vought; Douglas; Fairchild; Goodyear; Grumman; Lockheed; Martin; McDonnell; NorthAmerican; Northrop; Republic; A V Roe

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Barber-Colman's newest electronic control assembly, shown above, is recognized as outstanding in its class. Only Barber-Colman Company offers complete coverage of the automatic control field, cycling, full proportional, Micropulse, and electronic, for military, commercial, and executive aircraft.

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Available in sensitivities from 50 microwatts to 1 milliwatt. Wide range of coils, enclosures, mounting details. Extensively used in balance detecting bridge circuits and as plate current relay in electronic applications.

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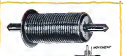

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An outstanding example of Lockheed's leadership — the F-94C is the third in the Starfire series and augments squadrons of F-94As and F-94Bs which have provided valiant protection for such key cities as New York and Washington, D.C.

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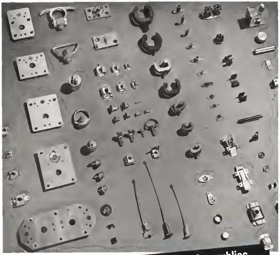

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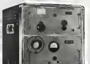
PRECISION RF TEST EQUIPMENT

THE SYMBOL OF QUALITY, ACCURACY, DEPENDABILITY

The equipments illustrated are typical examples of the complete line of PRD quality test components. Rigorously engineered and meticulously manufactured to the highest attainable standards, these units are now standard equipment in many of the leading research and development laboratories throughout the world. In addition to the widely diversified standard equipments offered, PRD maintains a highly qualified staff for special products development. This staff is at your service at all times for consultation.

Type 587
UHF FREQUENCY METER
470-900 mc/s

Type 801-A
UNIVERSAL KLYSTRON POWER SUPPLY
300-1500 V at 65 ma
1.5-3.6 KV at 25 ma



Type 854
UNIVERSAL SPECTRUM ANALYZER
8.5-8.6 kmc/s

Type 907
BROADBAND SWEEP FREQUENCY GENERATOR
40-900 mc/s

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Type 904
VHF-UHF NOISE GENERATOR
01-1.0 kmc/s

Type 275
VOLTAGE STANDING WAVE RATIO AMPLIFIER
300-3000 cps.

FREQUENCY MEASURING DEVICES

Frequency Meters	Frequency Range (kmc/sec)	Type No.	Transmission Line Size (Nominal O.D.—Inches)	R—Reaction T—Transmission
General Purpose	0.47–0.95	587	⅞	1
	2.40–3.40	583	⅞	R
	4.00–10.0	562-A	⅞	Detector included
	3.85–5.85	574	2 x 1	R
	5.85–8.20	575	1½ x ¾	R
	7.05–10.0	576	1¼ x ⅝	R
	8.2–10.0	585-A	1 x ½	R
	8.2–10.0	585-B	1 x ½	T
	8.2–10.0	586-A	1¼ x ⅝	R

In addition to the General Purpose Frequency Meters listed above PRD manufactures a complete line of Precision Frequency Meters covering the entire frequency range from 0.55 to 39.0 kmc/s. Transmission line sizes include ⅞" coaxial line and all standard wave guide sizes from 3.260" x 0.160" I.D. to 3" x 1" O.D. All types are available in Reaction and Transmission styles.
The Type 300 Frequency Standard Multiplier is available to generate standard frequency signals in the UHF and microwave regions when used with the Type 612 A Tunable Crystal Mount.

SIGNAL SOURCES AND RECEIVERS

ITEM	DESCRIPTION
TUBE MOUNTS	
Type 701	For type 2K28 klystrons, 2 400–3 445 kmc/sec
Type 722	For type 2K25 klystrons, 8 50–9 60 kmc/sec, 1¼x⅝ waveguide
Type 703	For type 2K25 klystrons, 8 50–9 60 kmc/sec, 1x½ waveguide
OSCILLATORS	
Type 705	Covering the frequency range from 7.0 to 11.0 kmc/sec
Type 706	Covering the frequency range from 3.6 to 7.3 kmc/sec
POWER SUPPLIES	Providing all required electrode voltages to operate a wide variety
Type 801-A	of klystrons, plus internal modulators
SPECTRUM ANALYZERS	
Type 853	Covering the frequency range from 2.40 to 3.40 kmc/sec
Type 854	Covering the frequency range from 8.50 to 9.60 kmc/sec
Type 855	Combining both of the above ranges in one instrument
GENERATORS	
Type 802	Covering the frequency range from 3.65 to 7.30 kmc/sec
Type 803	Covering the frequency range from 7.00 to 10.5 kmc/sec
Type 807	Covering the frequency range from 40 to 800 mc/sec
NOISE GENERATORS	For the direct measurement of noise factors in the range of
Type 904	10 to 1000 mc/sec

TRANSMISSION LINE SIZE

ITEM	COAXIAL (Nom. O.D. In.) ⅜	COAXIAL ⅞	WAVEGUIDE (Nominal O.D.—Inches) 3x1½	3x1	1½x¾	1¼x⅝	1x½	0.622x0.311 1.0	0.420x0.170 1.0	0.280x0.140 1.0
ATTENUATORS AND TERMINATIONS										
Variable Attenuators Uncalibrated			171	162	1156 161	160	154-B 159	189	196	191
Dial			174 A	189 B	177-B	184 A	196 C 196-D	187		
Precision			175-B	170 B	178-B	186 B	195-B	188-A	153-A	193
Cut-off		181,198					180			
Fixed Attenuators Low Power	136 series	130 series 1190-C	f	f	f	f	140 series	f		
Terminations	185	139	129	115	131	114	116	131	122	132
TRANSMISSION LINE COMPONENTS										
Waveguide to Coaxial Adapters			265	357	356	355	354-A			
Coaxial Transitions	389,390 391,392	389,390 391,393								
Directional Couplers				400	448	401	402	405		
Waveguide Stands			375 B	376 B	377 B	378-A	379-A	386 B	387-A	388 B
Flange Bolt & Nut Assemblies			369-A	369-B	369-B	369-C	369 D	369 E	f	f
Bends and Tees				s	s	s	462 465 881	s	s	s
IMPEDANCE MEASUREMENT & TRANSFORMATION										
Slotted Sections	200-C	205 B 215 B	209 B	201-B	204 B	203-B	203 A	210	211	212
Tuners		308	309	300	305	303	303 A	311 314	313	313
The Type 280 A Broadband Probe is designed for use with the Types 200-C through 209 A and 215 A Slotted Sections. Types 210-212 are supplied with built-in tunable probes. The Type 281 B F Adapter is available for use with the Type 280 A Probe										
DETECTION AND POWER MEASUREMENT										
Detector Mounts Crystal		612 B 613					601	616	831	615
Bolometer	(s)	613-B,613 627 A,628-B						616	636 631	618
Thermistor							635			
The Type 650 A Universal Power Bridge is designed to be used with any of the bolometers or thermistors listed for the measurement of absolute power level										

BOLOMETERS

TYPE No.	FOR USE WITH	TYPE No.	FOR USE WITH	TYPE No.	FOR USE WITH
610-A	350 B, 612-A, 613	639 B(s)	623(s)	620 B(s)	626(s)
614	310, 311, 616 631	629-B(s)	624(s)	631-C	637 B
817	312, 618 620	630 B(s)	625(s)	631 D	638 A

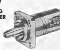
f—Equipment is supplied with captive flange screws
s—Available on special order only

Type 312
E/H TUNER
26.5–40.0 kmc/s

Type 196-B
VARIABLE ATTENUATOR
8.20-12.4 kmc/s
0-40 db

Type 211
PRECISION WAVEGUIDE SLOTTED SECTION
18.0–26.5 kmc/s

Type 585
DIRECT READING FREQUENCY METER
8.20-10.0 kmc/s



Type 389
COAXIAL TRANSMISSION LINE ADAPTER
0–4.0 kmc/s

Type 612-A
CRYSTAL BOLOMETER MOUNT
1.00–12.4 kmc/s

Type 650-A
UNIVERSAL POWER BRIDGE
0.1, 1.0, 10, 100 mw full scale

Type 627-A
BROADBAND COAXIAL BOLOMETER MOUNTS
5-10.0 kmc/s

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Our Magnetic Amplifier Division is now in production to meet your needs with custom designs or packaged units. The Type 2006 is a low level amplifier which will amplify a signal from a thermocouple, strain gauge, thermistor bridge, photo tube, etc., to operate an inductive meter or relay.

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F 84 G

F 84 F

RF 84 F

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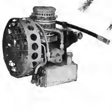

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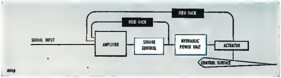

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Cutaway view showing O-rings. Illustration courtesy Vickers, Inc.

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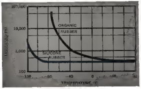

Flexible at —120 F. A glance at the blue curve shows the difference (Young's Modulus in flexure) of SE-550 versus organic rubber after 24 hours.

Compression test. Same-size pieces of ordinary silicone rubber and SE-360 are compressed for 22 hrs. at 350 F. Note how SE-360 (right) "comes back" to original size.

SE-100—IDEAL FOR ELECTRICAL AND MECHANICAL APPLICATIONS!

General Electric's new silicone rubber coating compound, SE-100, combines outstanding heat resistance, electrical and physical properties for a wide variety of electrical and mechanical applications. SE-100 may be coated on glass or organic fabrics for service at high or low temperatures or where resistance to weather, ozone, corona or chemicals is required.

SE-550—STILL FLEXIBLE AFTER 24 HOURS AT —120 F!

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SE-360—MORE "COME BACK" THAN ANY KNOWN RUBBER!

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O-rings, gaskets and seals are being designed with G.E.'s new SE-360 silicone rubber for applications where sustained resilience at high temperatures is required. Aircraft, automotive and railway design engineers find SE-360 ideal for jet engine parts, transmission seals and Diesel gaskets.

FOR MORE INFORMATION

about these new G-E silicone rubber compounds, just mail the coupon! You will also receive a free copy of "Imagineering with Silicone Rubber" which describes other G-E silicone rubber products and tells how you can put them to work.

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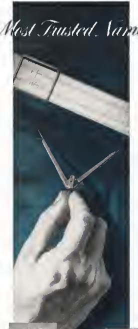

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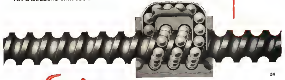

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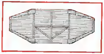

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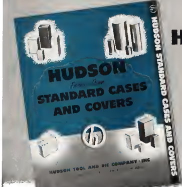

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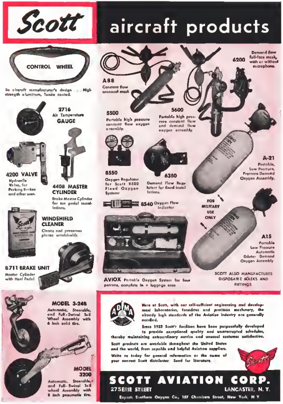

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Here's How This JOY AXIVANE® Aircraft Fan Solved a Problem of Unmatched Complexity

WHEN the Air Force and Consolidated Vultee, manufacturer of the B-36, decided it was necessary to have a pressurization booster on this king-size bomber, they really threw the design-book away. The requirements for the blower would cause any prospective fan supplier to have misgivings. Specifications called for three separate fan-duties:

Front View
(INLET)

Rear View
(OUTLET)

a *1180 CFM at 32″ W.G., with an air density of 0.044 lbs./cu. ft*

b *700 CFM at 40″ W.G., with an air density of 0.10 lbs./cu. ft.*

c *680 CFM at 26″ W.G., with an air density of 0.070 lbs./cu. ft*

Space and weight limitations were stringent. The fan had to operate without excessive horsepower requirements due to a critical load on the generators. In addition, the fan motor had to be protected from hot air in the duct system.

Just about when the job seemed impossible, it was turned over to Joy engineers.

The result? Not only was the problem solved to the complete satisfaction of both the Air Force and the manufacturer, but the prototype fan was in their hands only six months after Joy received the order.

The fan exactly meets the three duties specified. It is 10″ in diameter and 17″ in length. Because of its combination of magnesium and aluminum construction, the fan weighs only 54 lbs. It is a two-stage unit, driven by a two speed, 400-cycle motor. The efficiency of vaneaxial-fan design permits using a motor rated at only 12.6 H.P. continuous duty. The stationary vanes which support the motor are hollow, so that cooling air can be continuously directed over the motor. Each stage of the fan has a set of straightener vanes. Casing and hollow vanes are a single casting for shock-resistant strength.

● We freely admit that this is one of the toughest fan design-problems Joy engineers have ever tackled. On the other hand we are just as sure that, in the future, even harder problems will be taken on and solved. Even if your aircraft fan problem is not a difficult one, it is a good bet that the incomparable vaneaxial-fan design know-how which produced *this* AXIVANE fan will give you the most for *your* money. If you need an aircraft fan for any purpose, call on JOY—the world's largest manufacturer of vaneaxial fans.

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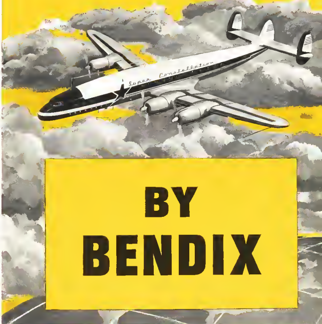


BY BENDIX

COMPLETE AVIATION RADIO BY BENDIX

★ VHF

Now you can receive . . . and transmit on 360 channels (from 118.0 to 135.95 MC) with a **single** finger tip control! No more confusing channel letters . . . no more conversion charts.

Fifty KC channel spacing provides maximum number of channels, and eliminates possibility of obsolescence for years to come.

RA-18B

TA-18BB

MN-81

RA-18B Receiver weighs only 18 pounds.
TA-18BB Transmitter provides 25 watts r-f output.
MN-81 Control Panel. Instant, finger tip control.

★ ADF

MN-62

This radio compass is the basic navigational system for all aircraft. It provides complete, automatic radio bearing information in the low and medium frequency bands.

Practically every multi-engine aircraft in the world carries the famous Bendix ADF.

MN-60

MN-58

MN-58 Dual Azimuth Indicator
MN-62 Radio Compass Receiver
MN-60 Hermetically Sealed Iron Core Loop Antenna

★ AUDIO

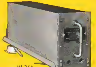
Complete audio equipment for paging, announcing, interphone and passenger entertainment systems for airlines and executive aircraft.

A high fidelity audio amplifier provides 20 watts output with very low distortion.

An Interphone Amplifier and Jack Box permits selection of eight receiver and three transmitter channels. (One crew member can be on marker beacon . . . another on radio compass and still another talking to pilot etc., without cross signal interference.)

A single package cockpit loudspeaker and amplifier eliminates need for constant pilot and crew use of headphones.

MS-92

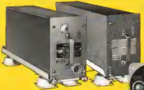


MI-36A

MI-51A

MS-92 Interphone Amplifier and Jack Box
MI-36A High Fidelity Audio Amplifier
MI-51A Cockpit Loudspeaker

★ MARKER



MN-53B MN-61B

IN-5

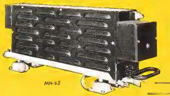
Accurate . . . simple . . . trouble free. No wonder this Marker Beacon is the standard for all the great airlines here and abroad. Bendix uses a 3-light indicator system. White for airway markers . . . amber for inner markers . . . purple for outer.

High and low sensitivity settings.

No relays used. No contact points to wear or burn out. No springs to vary in tension. No coil windings to open.

MN-53B Marker Receiver for executive aircraft. Weighs only 11½ lbs.
MN-61B Marker Receiver—½ ATR. Weighs only 13 lbs.
IN-5 Three Light Indicator

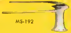
★ VOR



MN-85

MN-97

MN-81



MS-192

Complete use of every present VHF navigational facility with one system. The new Bendix NA-3A VHF Navigational System provides tone localizer (ILS), Visual Omni Range (VOR), Visual Aural Range (VAR), and communications reception on 280 crystal controlled channels.

RECEIVER

Furnishes continuous, clear navigational information . . . reliable, static free voice reception under IFR conditions.

OMNI-MAG

Presents a constant "moving picture" of the aircraft's position and heading relative to the selected course.

ANTENNA

The streamlined antenna in this VOR equipment is horizontally polarized. It is designed for broad band operation.

CONTROL PANEL

Finger tip control of the receiver is provided by this direct reading frequency selector. The famous Bendix "Do-Nite" system of illumination is used . . . white numerals during day, red numerals at night.

[SEE NEXT PAGE FOR MORE BENDIX AVIATION RADIO]

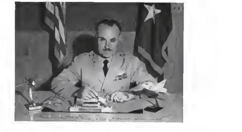
■ CONTENTS

AVIATION WEEK

ARDC EDITION

THE COVER

Research and development test aircraft and crack test pilots of the Air Force Flight Test Center are marshalled on the sun baked surface of Rogers Dry Lake which has saved several hundred million dollars in emergency landings The pilots are (A) Maj Charles Yeager, first man to fly faster than sound, (B) Maj Harold Russell, (C) Col Fred Ascani, (D) Brig Gen Stanley Holtoner, center commander, (E) Lt Col Jack Ridley, (F) Maj Arthur Murray The aircraft are 1) Northrop X 4, 2) Convair XF 92A Delta, 3) North American T 28A, 4) Lockheed F 80, 5) Republic F 84F, 6) North American F 86D, 7) Northrop F 89, 8) Lockheed F 94C, 9) Boeing B 47, 10) North American B 45 11) Boeing KC 97, 12) Convair B 36D



A MESSAGE FROM ARDC

Since the Wright Brothers' achievement fifty years ago, American scientists and engineers have met the challenge of flight with the necessary perseverance, courage, and skill to continue the progress of aviation. U. S. military aviation has been an outstanding contributor, and the latest step taken by the U. S. Air Force in furthering aviation's progress was the establishment in 1951 of a separate major command of the United States Air Force, to be called the Air Research and Development Command.

The challenging mission of the Air Research and Development Command is to assure the qualitative superiority of the United States Air Force.

To accomplish this mission the Command must coordinate the work of a productive team composed of those in the Air Force, in industry, and in science, who work together for our country's air progress.

Momentous advances are being made in flight today. The success the Air Force is having with the high performance of its piloted aircraft, as with its pilotless aircraft, is reassuring to the Nation.

Our air progress has been possible in the past and will continue in the future with the teamed effort of government, science, and industry.

D. L. Putt

D. L. Putt
Lieutenant General, USAF
Commander, ARDC

ARDC Molds U. S. Air Development

New Command fights the battle for technical supremacy, fosters liaison between industry-science team and military.

A new kind of air power is in the making. Combat aircraft are already coming off the drawing boards aimed at speeds of over 1,000 miles an hour. Missiles that can bridge the gap between continents are under development. Atomic weapons with the power that devastated Hiroshima are now packaged to fit fighter aircraft and missile warheads. Man has already survived at simulated altitudes of more than 100,000 ft. Monkeys have returned safely from rocket flights to the fringes of outer space.

The technological revolution that engulfed aviation during World War II has not yet run its course. It is on this rapidly expanding technical frontier of aviation that the Air Research and Development Command is fighting its share of the battle for air supremacy.

You can sense the shape and pace of this air power of the future from the airmen, officers and civilian scientists of ARDC who are manning outposts on the new technical frontier—in the air-conditioned coolness of a concrete missile-control blockhouse half buried in Florida sand . . . in the cockpit of a B-29 flitting into the fringe of atomic bomb clouds over Nevada wastelands . . . in the shimmering desert heat of a flight test center where pilots first pierced the sonic barrier and have already climbed to 80,000 ft. at speeds of more than 1,200 mph. . . . in the hot white glare of coral sand on a Caribbean island telemeter station . . . in the frigid white glare of a floating Arctic ice island weather research station . . . in the staccato fire of rivet guns, the clang of structural steel and the snorting of the bulldozers clawing out the largest aeronautical test facility the world has yet seen from among the red clay and jack oaks of southern Tennessee . . . and in the classrooms and laboratories of a hundred odd colleges and universities.

Emergence of the Air Research and Development Command as an independent organization on Apr 2, 1951, marked the recognition by USAF top policymakers, prodded by outstanding civilian scientists, that previous USAF research and development methods were "antiquated, incomplete in coverage, and failed badly in getting the most out of scientists in industry and universities" There was also a deep seated conviction that USAF was losing ground in the postwar race for technical supremacy and that a fundamental and decisive overhaul of its research and development effort would be necessary to improve its position

▶ **Quantity Did It**—It is generally recognized that the war in Europe was won with a superior quantity of arms despite the fact that the quality of American equipment, particularly in the final year, was often greatly inferior to that of the Germans

It has become equally obvious that in any future war the nature of the enemy will be such that the U S cannot hope to match his mass of manpower or materiel Any hope for victory must be pinned on superior strategy and technical superiority that can offset the effect of the enemy's mass

As Russia builds an atomic stockpile that will, for all effective purposes, match our own despite a continuing disparity in numbers, the importance of technically superior methods of bomb delivery will become increasingly decisive in the military equation And since USAF has the dual responsibility of delivering atomic weapons on enemy targets and parrying atomic thrusts by the enemy, its acute need for technically superior weapons systems can hardly be over-emphasized

▶ **New Accent on Quality**—To do this job effectively it became necessary to elevate quality, for the first time in USAF history, to equal rank with quantity Because the philosophy of quantity is represented by the Air Materiel Command, and most of the facilities that now comprise ARDC were formerly part of AMC, there was bound to be bitterness and dissension when the divorce occurred Although there is still some opposition at lower levels in USAF and among some parts of the aircraft industry, the wisdom of the decision to create ARDC becomes more apparent with the passing of time

Because it was part of Air Materiel Command, the qualitative viewpoint represented by research and development was always subordinate to the quantative viewpoint that represented AMC's primary mission of production. Just before the split, the Commanding General of AMC testified that he devoted 95% of his time to procurement problems and only 5% to those of research and development At the same time AMC was becoming so large and organizationally unwieldly that it became necessary to split its procurement authority into a geographically decentralized pattern (AVIATION WEEK Aug 4, 1952)

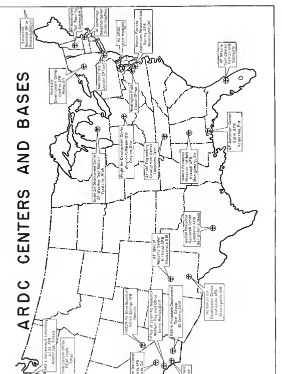
▶ **Two "Vice Presidents"**—Now USAF structure more closely resembles that of any large industry with separate vice presidents for engineering (ARDC) and production (AMC) at the same level and both reporting to the president and board of directors (USAF Chief of Staff and the Air Council) for decisions on major policies

At the same time ARDC was established as a separate command, a Deputy Chief of Staff for Development was added to the Air Staff, ranking with the Deputy for Materiel Although there remain a number of jurisdictional problems between ARDC and AMC, there is no longer any serious argument either in USAF or the aircraft industry that quality should again be subordinated to quantity or that one is more important than the other. To do its job properly USAF must have both

▶ **Air Force Job**—USAF has two principal missions

- First, to maintain an effective air force in being, capable of immediate and powerful action
- Second, to provide for a future force with performance that is fully abreast of the scientific and technological potential of the times and is technically superior to the enemy's weapons

The first mission is primarily that of USAF combat commands, supported quantatively by AMC and qualitatively by ARDC All of the USAF equipment now in production was developed



SUPERSONIC PROPELLER research is speeded by twin-jet McDonnell XF-88B flying test bed with turboprop in nose.

before ARDC existed and some of these production programs are excellent examples of excessive expenditure of time and money resulting from flaws in the former development pattern. However, ARDC also has responsibility for development work and in-service engineering on USAF equipment throughout its life in the active service inventory. Considerable effort is now being spent on specific technical fix programs required for equipment already in production or service.

The second mission is the primary job of ARDC. A sound research and development program is the foundation for a good production program. Unless quality is achieved first there is little point in compounding inferiority by multiplication.

▶ **Budget Fluctuations**—A major problem in developing a sound qualitative foundation for future production programs is counteracting the effects of the annual fluctuations of the defense budget. Unless development projects and research programs can be planned and financed over normal development cycles that will insure completion of the work involved they will produce few tangible benefits.

A good example of what budget fluctuations can do to development programs is the current USAF lack of turboprop engines. Millions of dollars were poured into turboprop development but budget fluctuations produced a start-stop effect on these programs that eventually produced nothing in the way of an operational engine.

A solution seems to be stabilization of the research and development budget over five year periods and allowing the budget fluctuations to be absorbed in other areas where the relationship between world tensions and increased budgets is more direct. It would appear that a more stabilized budget is practical since current R&D expenditures are running about a half billion dollars annually—less than 10% of procurement funds and only about 2% of the total USAF annual budget.

Mission

In official language, USAF has defined the ARDC mission as follows:

- **Attain and maintain** qualitative superiority of materiel and conduct or supervise scientific and technical studies required for the establishment of the Air Force mission.
- **Seek basic new knowledge** from which improved aeronautical equipment materiel weapons and techniques can be developed.
- **Undertake the development** and recommend adoption of appropriate new and improved devices and systems for the conduct of and support of air warfare, including aircraft, missiles, weapons, techniques and procedures applicable to Air Force purposes.

"We are trying to function primarily as a proper liaison between the military operators who need new and better equipment and the scientific brains of the industrial and academic worlds who can develop it or contribute knowledge to the development problems," says Lt. Gen. Donald L. Putt, ARDC Commander.

"ARDC's job is not to actually do the research and development job," Putt says. "For that we rely primarily on industry, universities and civilian research organizations. Our job is to tell these groups the problems the Air Force wants to solve and to program, finance, monitor and evaluate the work necessary to solve them. In turn we keep the Air Force informed on the kind of equipment they are likely to get at any given time because of the 'state of the art' in any particular field."

▶ **Help From Outside**. The only research and development work ARDC does in its own facilities is that necessary in support of its test facilities or work to advance the state of the art in fields where industrial or academic sources are not sufficiently interested to tackle the job. ARDC now spends 57% of its R&D money with civilian contractors. This contrasts with 65% spent by the Navy and 45% by the Army.

ARDC is trying hard to avoid building a large military overhead wherever possible. It is relying on civilian organizations which usually have more of the flexibility necessary in technical work, more and better trained personnel, and a continuity that is lacking in military organizations and is so necessary in scientific and technical work. ARDC's policy toward industry is:

- **Encourage new segments** of industry to become interested in Air Force problems.
- **Give industry** more responsibility for development work.
- **Keep industry better informed** on USAF problems and requirements.
- **Create and operate development** test facilities that industry needs for USAF work, but which are too expensive for any individual industrial group to finance and support.

Another way in which ARDC is attempting to avoid building a large military overhead is by getting civilian contractors to operate its major test facilities wherever feasible. The Arnold Engineering Development Center is operated by Aro, Inc., a subsidiary of Sverdrup & Parcel, St. Louis consulting engineering firm. Instrumentation for the Joint Army-Air Force Missile Range at Alamogordo, N. M., is operated and maintained by Land-Air, Inc., a civilian electronics contractor.

ARDC is currently negotiating with Pan American World Airways and Radio Corporation of America to operate the 1,000-mile missile test range in the Caribbean.

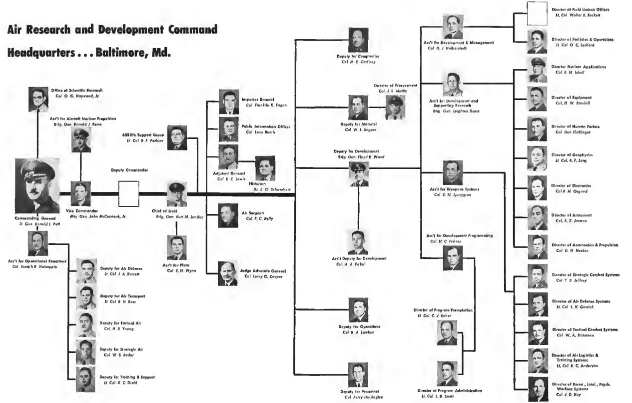
ARDC's Work

Most of ARDC's work falls into the following categories:

▶ **Basic Research**—Basic research is currently a 55 million annual program aimed at attempting to refill the reser-

Air Research and Development Command

Headquarters . . . Baltimore, Md.



voir of basic knowledge in the physical sciences that was virtually drained during the frantic development work of World War II. It is administered largely by the Office of Scientific Research. The bulk of this work is done under contract by university scientists and civilian research organizations. A small portion of the work is done in ARDC centers.

Basic research is one of the most important parts of the ARDC program and perhaps the hardest to sell to higher level Defense Department officials and Congress because it offers no specific promise of new hardware. Yet such vital items of new hardware as radar, atomic bombs and electronic transistors were possible only because of basic research in their fields that at the time held no hope for the ultimate products and was not even aimed in their direction.

Another example is the basic research done on the behavior of a bull's sperm which eventually led to the discovery of a drug that can prevent fatigue for specific time periods. The value of this for long-range bomber crews and fighter pilots is obvious, yet it is easy to imagine the irate snort of a member of the House Appropriation's Committee when asked to approve an item for bull sperm research in the defense budget.

During the 83rd Congress, an ARDC contract with Harvard for a study of the Russian social system was widely denounced as "boondoggling." Yet the lack of such basic knowledge of the German and Japanese social systems in World War II cost the lives of many airmen, the unnecessary expenditure of millions of dollars of equipment and prolonged the war.

One of the lessons learned from the German scientific success in guided missiles and failure in electronics was the value of applying all of the basic research knowledge produced by the universities and colleges to specific programs. ARDC is not only tapping the best scientific brains in this country but is also reaching out to use intellectual resources on the right side of the Iron Curtain in Europe.

▶ **Applied Research**—This is currently a $342-million annual program of which 85% is spent by contractors. It includes both research aimed at specific "state of the art" advancements and development work against specific military requirements. The ARDC laboratories at Wright Air Development Center, Rome Air Development Center and Cambridge Air Force Research Center do the applied research not farmed out to contractors. Applied research is all aimed at the eventual production of "hardware" necessary for the Air Force to perform its missions.

▶ **Testing**—ARDC is now engaged in an expensive and extensive effort to make up for the lost postwar time in providing the type of development testing facilities required by industry and the Air Force for the new spectrums of aeronautical performance. Although the dollars now piled up in a backlog of tardy construction programs is large enough to make congressmen squirm, it represents false economy to continue delaying these vitally needed facilities.

In the five years that construction of the engine test facility at AEDC was delayed by political football, USAF lost more than its cost in the poor performance of one of its jet engines at altitude. During this period there were no adequate high-altitude engine test facilities in which to work out the "bugs" that were destroying both expensive aircraft and expensive pilots.

The type of facilities required for testing modern air weapons systems are so large and complex that no company in the aircraft industry could afford to build or operate them individually. For guided missiles, a fully instrumented range at least 1,000 miles long is now required. For rocket engines alone, something that will anchor a million pounds of thrust will soon be required. For experimental supersonic aircraft, runways 15,000 ft. long for takeoff and 10 to 15 miles long and a mile wide for safe emergency landings are required to do the job properly.

USAF, through ARDC, is financing the construction and operation of such types of facilities and will offer their use to contractors who are developing hardware for USAF weapons systems. Among these facilities in operation or under construction are:

• **Windtunnels** for testing transonic and supersonic aircraft and their propulsion systems at altitudes up of 80,000 ft., at AEDC.

• **Long-range missile test** range with 1,000 miles of fully instrumented range and a 7,500 ft. landing strip where missiles can be safely recovered after a 2,000 mile flight, at Patrick AFB.

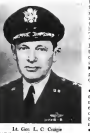
• **Short range missile test** range for early test work involving maneuverability, recovery and air-to-air operations, at Holloman AFB.

• **Rocket test center** that can handle motors of half a million pounds thrust now, and eventually can test a million pounds thrust, at Edwards AFB.

• **Supersonic sleds** operating on precision railroad tracks for highspeed testing of aerodynamics, auxiliary equipment and decelleration at Edwards and Holloman.

• **Armament range** for testing rockets, bombs, air-to-air missiles and new types of aircraft cannon, fire control systems, etc. at Eglin AFB.

• **Flight test center** for highspeed aircraft, with 350 flying days a year, takeoff runway of 15,000 ft. and a solid strip 22 miles long and a mile wide for safe emergency landings, at Edwards.


Lt. Gen. L. C. Craigie
USAF Deputy Chief of Staff/Development

After ARDC has researched, developed and tested a weapons system, it goes to the Air Proving Ground Command, an independent agency for proving out to determine its suitability as a weapon ready to be used by the combat commands of USAF.

Because so much of the development on aircraft is done after production has begun, ARDC now has the engineering responsibility for all changes in the aircraft or equipment that affect the quality of its performance throughout the life of the equipment in the USAF active service inventory. This is at present a bone of contention between ARDC and AMC. This concept may be modified from its present "cradle to grave" cycle to something approaching "cradle to maturity," with engineering responsibility switching completely to AMC once an item of equipment has left its major development behind. This would cover a variety of USAF "cats and dogs" such as C-46s, B-29s, B-25s, C-45s, P-51s and others still in the active inventory but with no significant development left in their tired old airframes.

▶ **Other Jobs**—ARDC has also been given two other jobs in line with its qualitative mission.

They are:

• **Engineering standards**. ARDC takes engineering specifications proposed by manufacturers of every type of USAF equipment, from B-52 bombers to office chairs, and revises and approves them as a standard for AMC procurement.

• **In-service engineering**. ARDC now handles all Unsatisfactory Reports from USAF field units that contain technical complaints. These are handled through Wright Air Development Center via a decentralized system that fits AMC's decentralized materiel areas. WADC has a technical representative at each of the 12 AMC materiel area headquarters to handle URs on equipment procured through the air materiel area.

Originally a bottleneck developed when WADC laboratories tried to handle the URs, but now the majority of them are farmed out to manufacturers of the equipment involved for solution with WADC monitoring. Increasing reliance on the industry to handle UR's has cut the average time it takes to get a "fix" to 30 days from an earlier average of 120 days.

Organization

ARDC headquarters is the nerve center of the new USAF technical development program. It is now located in two downtown office buildings in Baltimore, Md., but there are plans for building a permanent headquarters on the edge of Friendship Airport south of Baltimore.

One of the considerations in locating at Baltimore was that it would enable ARDC to maintain close liaison with USAF headquarters and other military research organizations without taxing the already overloaded military installations in the Washington area.

ARDC headquarters is organized along the same functional lines as USAF headquarters with the exception of three offices which are peculiar to ARDC mission. They are:

• **Office of Scientific Research,** now headed by Col. Oliver G. Heywood, Jr.

• **Office of the Assistant for Operational Readiness,** now headed by Col. Joseph R. Holzapple.

• **Office of the Deputy for Development,** now headed by Brig. Gen. Floyd B. Wood.

Work of OSR is described in article starting on p. 87.

▶ **Readiness Teams**—The Assistant for Operational Readiness reports directly to ARDC and heads a group of "traveling salesmen" who maintain extremely close liaison between ARDC and the operational USAF commands that use weapons and supporting systems.

There is a team from this office working with every major user command: Strategic Air Command, Tactical Air Command, Air Defense Command, Air Training Command, and Military Air Transport Service.

Team's job is to get the ideas of operational personnel down to wing and squadron level "cranked in" to ARDC's technical thinking and to keep the user commands conversant with the "state of the art" in their particular fields of interest. Operational Readiness maintained a permanent liaison team with USAF combat units in Korea during the war there and sends special missions to overseas theaters on specific operational problems.

▶ **Development Activities**—There is a conventional Deputy for Operations on the ARDC staff, to handle normal housekeeping and management functions leaving the Deputy for Development free to handle the technical program of the Command. The character of ARDC's development activities can readily be discerned from the signs on the office doors of section chiefs under the Deputy for Development. The Weapons Systems Division has the following subdivisions:

• **Strategic Combat Systems**
• **Tactical Combat Systems**
• **Air Defense Systems**
• **Air Logistics and Training Systems**
• **Reconnaissance, Intelligence and Psychological Warfare Systems.**

▶ **Technical Directorates**—These offices are responsible for systems development in their particular field and draw on the seven technical directorates for specific developments in their fields to support the weapons system development programs.

The technical directorates are:

• **Aeronautics and Propulsion.** This directorate is divided into two sections. The aeronautics section handles aerodynamics, structural development, design criteria, landing gears, controls and actuating systems, escape systems and miscellaneous development. The propulsion section handles piston and gas turbine engines, nuclear propulsion, fuels, lubricants, and engine accessories.

• **Armament.** This directorate operates in four sections—systems engineering, air ordnance, special weapons and foreign development. It covers offensive and defense armament systems, fire control systems, nuclear weapons, gunsights, bombing and navigation systems, air-to-air and air-to-ground missiles, etc.


Lt. Gen. Earle Partridge came from Korea to command ARDC.

• **Electronics.** This includes airborne and ground radar, communications and navigational aids, electronic countermeasures, and special electronic devices.

• **Equipment.** This directorate handles the widest variety of projects in ARDC. It has six subdivisions:

1. **Ground** equipment, which includes all airbase support equipment such as refueling vehicles, tractors, snow plows, runway lighting systems, hangars, weapons and missile support equipment and training equipment.
2. **Airborne equipment,** which includes all airborne instruments, airborne electrical and mechanical systems, integral cargo loaders and tie down systems.
3. **Uniform and personnel** equipment, which includes clothing, rescue and survival equipment, parachutes and miscellaneous equipment.
4. **Photographic** equipment, which includes photo laboratories, both fixed and portable, mapping and charting equipment, and photo-recon equipment.
5. **Meteorological** equipment, which includes all kinds of weather observing, recording and correlating equipment, except those types assigned to the Air Weather Service.
6. **Material,** which does all the applied research on all types of materials used by USAF.

• **Geophysics.** Work in the field of terrestrial sciences and atmospheric physics and forecasting is aimed not only for use in weather work but also for the effects of the atmosphere on actual operations of missiles, aircraft and communications.

• **Human factors.** This directorate operates in three sections:

1. **Aeromedical sciences,** including aviation medicine, protective equipment and bio-medical aspects of radiological and chemical warfare.
2. **Human engineering,** including design, development and field evaluation work to match airmen and their equipment better.
3. **Human resources,** including social-psychological work to improve human relations and morale, utilize manpower more efficiently and improve training methods.

ARDC has also recently acquired three field stations that have been working the human factors field. They are:

1. **Human Resources Research Institute** at Maxwell AFB, commanded by Maj. Gen. Franklin O. Carroll. This center works in the field of cultural research,

studying the individual in relation to his environment. Specific fields include psychological warfare, strategic intelligence and counter-intelligence and morale factors. Dr. Carroll L. Shartle is director of research.

2. **Human Resources Center** at Lackland AFB, commanded by Col. Herbert Cowles. This center covers the entire field of psychological research aimed at developing better methods of personnel classification, training and job proficiency measurement.

3. **Human Factors Operations Laboratory** at Bolling AFB, headed by Karl D. Kryter, evaluates the human factors under actual operational conditions encountered by air crews in specific aircraft and operating specific airborne equipment.

• **Nuclear applications.** This directorate is concerned with testing of atomic weapons and their effectiveness, defensive measures against atomic attacks and the best methods of employing fissionable materials in warfare.

ARDC also is responsible for the Armed Services Technical Information Agency (ASTIA) located at Dayton.

Procurement

USAF has defined the procurement responsibilities of AMC and ARDC so that the former buys all standard USAF equipment required by ARDC and ARDC buys all non-standard equipment peculiar to its mission. In practice this now means that ARDC buys all of its research and its development in the field of armament. On major weapons systems and specific aircraft development, ARDC assists in selection of a contractor but AMC writes the contract. For standard type USAF equipment required by ARDC, the individual ARDC centers initiate procurement requests which are funneled through the Director of Procurement at ARDC headquarters, Col. Robert Martin, and then to AMC for processing.

Buying of research and development differs sharply from buying production hardware and ARDC is trying to tailor special methods best suited for its type of procurement within the framework of the armed services procurement laws.

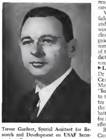
For example, since research contracts buy primarily the time and effort of specially talented individuals or organizations, the primary consideration in picking a contractor are his qualifications rather than price. The primary problem in buying research is to select the most qualified source to do the particular investigation required. ARDC now uses a conference type negotiation in which prospective contractors are briefed on the technical requirements and funds available for the project and requested to submit proposals. ARDC technical officers are responsible for evaluating the proposals and ARDC procurement officers are responsible for fitting the proposals within the framework of existing USAF procurement regulations.

Fixed-price contracts are generally not suitable for buying research. Cost-plus-fixed-fee types are used when a fixed development goal is sought, while a target-ceiling type contract is generally used when the project requires initial exploration of a subject and no fixed goal is in sight. In the target-ceiling contract, the contractor is given a dollar ceiling within which to work for a specified time period with provision for redetermination at the end of the period. If the contractor exceeds the dollar ceiling, he stands the extra cost; if he is below the ceiling, part of the difference is added to his fee.

To understand the present structure of the USAF research and development effort and the problems facing ARDC it is necessary to take a backward look to see how the present race for technical superiority developed.

Before World War II, the Army Air Corps procurement effort was so small and its inventory turn-over so slow that few industrial groups outside the airframe and engine industry were interested in doing aviation work.

Turnover of the prewar Air Corps inventory was so slow that planes delivered in 1927 were still being flown as first line fighters and bombers 10 years later. Now the swift pace of technical development has dictated a three-year turnover in USAF inventory of first line aircraft, with an additional three years of service in the second line—Reserve, National Guard and training units.


Trevor Gardner, Special Assistant for Research and Development on USAF Secretary's staff

▶ **Was Just in Time**—When the war began in Europe in 1939 the first aerial combat indicated clearly that both British and German production-model combat planes were superior to those then coming out of U. S. aircraft factories. An attempt to organize a large-scale technical development program soon succumbed to the pressure for quantity production to produce an Air Force in being.

The wartime years saw the continued emphasis on quantity production at the expense of quality. A series of costly post-production modification programs that belatedly attempted to build in the quality required for combat that had been neglected on the production line were required for most Army Air Forces planes.

The end of the war revealed clearly that it had been won just in time since the Germans were bringing into play technically superior weapons that the AAF would have been unable to match.

Getting Started

The late Gen. H. H. "Hap" Arnold was an early missionary for increased research and development in the Air Corps and pioneered the use of civilian scientists to advise the Army Air Forces on technical methods of solving their military problems. Late in 1944 he roused Dr. Theodore von Karman from a sickbed in New Jersey to fly to Europe and make a survey on enemy technical developments in relation to those of the Allies.

In two reports, "Where We Stand" and "Science: Key to Air Supremacy," Dr. von Karman detailed where the AAF had lagged behind the Germans in technical developments and what it must do to recapture the lead in the race for technical superiority.

While U. S. had been superior in the fields of electronics, atomic weapons and the perfection of the laminar flow wing for subsonic aircraft, the Germans clearly led in jet propulsion, rockets, guided missiles and supersonic aerodynamics. On the basis of the research of that time Dr. von Karman flatly predicted that the era of supersonic flight was just around the corner.

▶ **LeMay Takes Over**—To implement Dr. von Karman's recommendations, Gen. Arnold brought Gen. Curtis LeMay, who he characterized as the AAF's "finest combat leader," to the Pentagon to take the newly created role of Director of Research and Development on the Air Staff. LeMay fought a valiant battle for two years but the pressure for a force in being again submerged the effort to build future quality.

Before he left for the Strategic Air Command, Gen. LeMay had accomplished two significant things:

• **He had established** the Rand Corp., which still provides scientific guidance for USAF on military problems.

• **He organized** the Air Force Institute of Technology to train the combat veterans of World War II in the technical problems of tomorrow.

▶ **Birth Pangs**—When USAF was created as a separate service, its immediate problems of divorce from the Army tended to obscure the critical technical problems it faced for the future. These were:

• **Lack of adequate development testing** facilities for the new generation of aircraft and missiles. During World War II the U.S. was so short on aeronautical test facilities that the basic aeronautical research facilities of the National Advisory Committee for Aeronautics were drafted to do the critical development testing for specific fixes on Air Force and Navy aircraft required for the war. The few facilities operated by the Air Force and Navy were hopelessly obsolete to cope with the postwar technological revolution in aviation.

• **Lack of adequately educated and** trained personnel in the technical fields required for the new era of aviation. A survey of Wright Field officers holding technical posts within AMC in 1947 revealed that 60% did not have the necessary technical qualifications to even qualify them for entrance to the Air Force Institute of Technology—the school that was supposed to train people for the jobs they were already filling.

• **Lack of adequate priority**, funds and command of the research and development facilities already existing. The Wright Field technical laboratories were under AMC. The Special Weapons Command, the Arnold Engineering Development Center and the Long Range Missile Proving Ground were all independent organizations. The electronics laboratories in New Jersey and Massachusetts were operating as exempt facilities with their own procurement authority although nominally under AMC control.

▶ **"Old Shoes"**—The aircraft industry was in a state of revolt because there were no development funds to push forward into the technical gaps already yawning in highspeed aircraft, jet propulsion and guided missile fields. Although the first piloted supersonic flight was made in the fall of 1947 as a milestone in the brilliantly planned and executed highspeed flight research program of USAF, Navy and NACA, there were no funds for new aircraft prototype development from 1947 to 1949. New aircraft development had to be financed out of production funds by modifying subsonic types already in production or "resoling old shoes," as one industry veteran cynically described the process.

The Defense Department Research and Development Board became known as the "Retardation and Delay Board," as its 16 committees, 174 panels, 284 sub-panels and 3,000 special consultants debated endlessly without decisive action. Prominent civilian scientists seriously proposed that the research and development functions of the defense department be turned over to civilians.

▶ **Ridenour Committee**—By 1949 the research and development issue had become a hot controversy both in the Air Force and the Defense Department, where Defense Secretary Louis Johnson was preaching his doctrine of false economy. Gen. Vandenberg, then USAF Chief of Staff, appointed a committee of the USAF Scientific Advisory Board, headed by Dr. Louis N. Ridenour, then Dean of the University of Illinois Graduate School, to study the USAF problem.

A significant member of this group was Dr. James Harold Doolittle, who combined distinguished service as an aeronautical scientist, USAF combat commander and industrial leader. Later as Special Assistant on Technical Matters to the USAF Chief of Staff, Doolittle played an important role in the establishment of ARDC and the explanation of its philosophy to the aircraft and related industries.

▶ **Development Deficiencies**—The Ridenour Committee report noted the following deficiencies in the USAF development program:

• **Too low a priority**, both on the Air Staff and in USAF operational command, was assigned research and development activities.

• **Research and Development** activities were diffused throughout the Air Force with no single responsible agency either at the staff or command level.

• **Too few officers and civilians** in the Air Force had the proper technical qualifications.

• **USAF facilities were inadequate for** both the research and development effort required to keep up scientific pace.


ARDC Insignia

▶ **Recommendations**—The committee recommended that a research and development command be established in which all of the USAF R&D mission and facilities should be concentrated.

A similar study was also made by an Air University group composed of military experts headed by Maj. Gen. Orville Anderson. Their conclusions were substantially the same as those of the Ridenour Committee.

On Jan. 3, 1950, the late Gen. Muir Fairchild announced to an Air Staff meeting that a Deputy Chief of Staff for Development would be appointed, and the Air Research and Development Command would be activated. Maj. Gen. Gordon Saville was named first Deputy Chief of Staff for Development. Lt. Gen. L. C. Craigie now fills the post.

Maj. Gen. David Schlatter was transferred from the USAF atomic weapons program to organize the new command. Later a special civilian post was created for a research and development advisor to the Secretary of the Air Force. This position is now filled by Trevor Gardner.

▶ **ARDC Takes Over**—The process of unsticking the major components of the new ARDC from AMC dragged out for over a year. Not until long after the outbreak of war in Korea was the command finally activated as an independent organization on Apr. 2, 1951.

A few months later the appearance of the Russian-designed and -manufactured MiG-15 and La-17 sweptwing jet fighters over North Korea served notice that the Soviets were not lagging in modern aircraft development.

During the past two years, under the command of Lt. Gen. Earle Partridge, ARDC has gradually been given control of the previously scattered USAF research and development units. Gen. Partridge was recently named deputy USAF Chief of Staff for Operations and was succeeded at ARDC by Gen. Putt.

The Ridenour report warned USAF that it would be at least five years after establishment of a new research and development command before any progress could be noted. In the two years of its existence, ARDC has made substantial progress toward eliminating major defects that threatened USAF technical progress with stagnation. It still faces many unsolved problems, some inherited and some inherent in the swift technical pace of modern air power.

The real importance of ARDC lies in the fact that it has been created, organized and is working to put the technical future of USAF on a sounder foundation. How well it will do this job only the future can tell. But few will deny ARDC has made a significant start.

Weapon System Plan Spurs Development

New military-industry relationships foreshadowed by single prime contracts, revised design study procedure and JPOs.

Success or failure of the Air Research and Development Command will be measured primarily by the quality of the new weapons developed under its auspices and the speed with which these weapons progress from the drawing board to combat units.

ARDC, with USAF approval, has already initiated a program aimed at compressing the development cycle; raising the quality of USAF weapons closer to the current technical "state of the art"; and cutting the cost required for weapons development.

While these steps will require another three to five years before their effects can be accurately gauged they foreshadow significant changes in the aircraft industry's future methods of doing business with the Air Force. They have also altered relationships between prime contractors, components manufacturers and suppliers within the aircraft industry.

The ARDC weapons development program includes

- **Weapons system concept** This aims at producing a complete weapons system including all of the equipment required to perform a specific military task instead of simply an aircraft with miscellaneous assortment of hardware that must be jiggered into a combat system in the field with some parts incompatible or missing.
- **New design competition procedure.** Instead of giving the industry a detailed specification for a new aircraft or missile, the procedure emphasizes the military requirement to be met and relies on the industry to produce a technical solution It plans to compensate the industry for its preliminary design proposal work in providing solutions for weapons system contracts even though the individual firm does not win the systems development contract.
- **Single prime contractors.** ARDC plans to buy the management talents of the aircraft industry in organizing and scheduling weapons system development as well as its technical skill in developing the system
- **Joint project office.** Establishment of the Joint Project Offices at Wright Air Development Center provides the industry with a single focal point for its relations with USAF during the development cycle of a weapons system.
- **Controlled production buildup.** This plan has been endorsed by ARDC and Air Materiel Command and approved by the Air Council. It calls for production tooling and initial production at relatively low rates to produce a larger number of test models It defers quantity production until sufficient data is obtained from the development testing program to insure elimination of major "bugs" that inevitably plague new aircraft and related equipment.

▶ **Missile Problem**—This program developed out of the bitter experience of USAF in World War II and has been sharply spurred by the technological revolution that hit aviation in the postwar years The advent of guided missiles and supersonic aircraft made it evident that new development methods were required Much of the pattern of the present development program first emerged when USAF faced the missile problem in the early postwar years

- Since there was no previous missile experience the military could only state their requirement and rely on the industry to produce technical solutions.
- A missile by its very nature had to be a complete weapons system and had to be approached from that angle
- Since there was no missile industry in existence the contractors pioneering the field had to be given complete responsibility for systems development
- And since it appeared that missiles would be a one shot affair it was necessary to manufacture a substantial quantity for testing during development before a decision could be made on the final equipment for quantity production

▶ **Weapons Systems**—USAF is developing its new weapons as a complete system that will include all of the equipment needed to do a specific military mission Development and production is scheduled so that all parts of the system are available and workable when the system is scheduled to go into use

"You can think of the entire USAF as a large complex weapons system which is in turn a sub system of the entire Defense Department," says Col Ernest Ljunggren, head of ARDC's Weapons System Division "Each command within USAF is a lower sub-system and each weapons system within the Commands a still lower sub system. Each sub system must operate within the restraints imposed by the next higher system

"For example, USAF must operate within the limits of critical materials that will be allocated to it by the Defense Department Weapons systems must utilize a certain percentage of standardized parts because of the logistical restraints imposed by USAF operations as a whole It is the job of the contractor to develop the optimum weapons system within the restraints imposed by the next highest system We don't plan to optimize the system at the expense of its components nor optimize the components at the expense of the system."

▶ **Supersonic Problem**—The achievement of supersonic flight in piloted planes made the applications of the weapons system concept mandatory to future aircraft development

"We can no longer afford to order an airframe and then try to stuff it with government furnished equipment developed separately under separate contracts," says Col H A Boushey, chief of the Weapons System Division at Wright Air Development Center "From now on the faster aircraft go, the more exactly we must tailor our power, aerodynamics, guidance and firepower to fit each other in a single airframe package You just can't consider less than the whole problem and be successful"

Another significant facet of the weapons system concept is the recognition of realistic development scheduling problems and the necessity for realistic planning to have all of the components of the system ready for production at the same time so that the industry can produce and deliver combat ready equipment

"We must recognize that it takes from seven to ten years to develop a new fire control, bombing and navigation system or powerplant type whereas an airframe can be developed in 2 to 3 years," says a top civilian technician long associated with aircraft development "In World War II, the technical ingenuity of the combat units in the field enabled them to modify the equipment we gave them to fill in the gaps and do the fighting job This saved the system from collapse But modern aircraft are too complex to be modified in the field They must be right when they roll off the production line equipped with all the hardware they need to do a military job."

▶ **World War II Tries**—Initial attempts to apply a systems approach to aircraft development were made during the latter phases of World War II with the B 29 as a strategic bombing system and the Northrop P-61 as an all-weather fighter system with components required for the combat mission tailored specifically to the aircraft

The first significant stride in the direction of the present weapons system concept was made in the summer of 1949, when Maj Gen Gordon Saville, then Director of USAF Requirements, backed by the late Gen Muir Fairchild, then USAF Vice-Chief of Staff, called in the aircraft industry to the Pentagon for a briefing on air defense problems of the future and asked the industry to provide technical solutions

This resulted in the all-weather interceptor competition won by Convair with the F-102 design The interceptor development was handled essentially as development of two separate systems the aircraft by Convair and the fire control, electronic guidance and offensive armament system by Hughes Aircraft

Out of this grew the full-scale systems concept now being applied to the development of strategic bombing systems, tactical combat systems, air defense systems, aerial logistics systems, and strategic reconnaissance and intelligence systems

▶ **Industry's Reaction**—There was considerable aircraft industry opposition to the introduction of the weapons system concept and the proposal to utilize a single prime contractor to assume systems development responsibility But so far Convair, Douglas, Boeing, Lockheed, Martin and others have organized systems engineering groups

Convair has also revamped its division organization and management on a weapons systems basis with the Ft Worth Division assigned responsibility for strategic bombing, aerial reconnaissance and aerial logistics systems and the San Diego Division charged with handling air defense systems and Navy water based aircraft systems All of these activities are coordinated by a special long-range planning group charged with keeping top management informed on technical trends and military requirements in the systems fields

▶ **ARDC as Monitor**—The key to the systems development is the new procedure developed by ARDC and approved by USAF for handling new weapons development Basically it calls for USAF to define the military problem for which it requires a solution and then to rely on the industry to produce the best technical answers ARDC's role is to monitor, evaluate and supervise the development program and, with Air Materiel Command, recommend and select competent industry management-technical-production teams to do the job

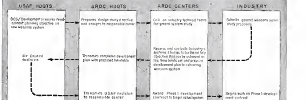
Here in detail is how this new procedure works The process begins with the writing of a Development Planning Objective by the Director of Development Planning (now Brig Gen B S Schriever) in the office of the Deputy USAF Chief of Staff for Development (now Lt Gen L C Craigie)

The DPO is the broad qualitative analysis on which initiation of requests for new weapons systems is based It includes a survey of strategic, logistic and technical considerations; a study on the feasible time limits for the system development; and outlines new research and development programs that may be required for long lead time components such as bombing and navigation systems, engines and electronic fire control systems

ARDC through its technical directorates and systems offices and centers assists the Deputy for Development in determining technical feasibility and the Rand Corp makes studies on military problems involved

▶ **Operational Requirement**—The development of a specific weapons system is initiated by a General Operational Requirement in which USAF headquarters states the military problem it wants solved and requests ARDC to develop a solution Included in the GOR are such factors as types of missions the system must perform, types of targets it must attack, the environment in which it must operate; the enemy capabilities it must surmount; and logistical requirements and limitations

ARDC again draws on its technical directorates, weapons system offices and centers to organize a Design Study Directive which is prepared for the technical guidance of all military and industry organizations concerned with the effort to plan a complete systems development program The Design Study Directive assigns responsibility for development of each system to a particular ARDC center As a matter of actual practice, virtually all major systems are handled through Wright Air Development Center through the Weapons Systems Division, headed by Col H A Boushey and operating under the WADC deputy for operations, Col



Victor Haugen. All aircraft and missile systems are handled through WADC but some ground systems, particularly avionics, are handled through Rome and Cambridge.

▶ **Target Set**—The Design Study Directive sets target dates for systems completion, specifies research and development funds available to support preliminary studies, establishes priorities for the projects, outlines co-ordination required between centers and lists any parallel developments that should be considered in planning the new system. Attached to the Design Study Directive is an appendix containing the original GOR, a technical guidance memo, suggested development goals, applicable projects already under development, areas that require exploration, limiting policy factors, and an intelligence annex.

The ARDC center assigned the system responsibility then calls in the industry to study approaches to the operational problem involved and this is where the ARDC-industry partnership actually begins to work. ARDC feels that bringing industry into the military development picture at this early stage will give it a better picture of the military customer's needs and give the military a better fix on what it is feasible to get technically from industry during any given time period.

ARDC functions as a liaison between the military commanders who need equipment to do their job and the industry that must provide the equipment.

▶ **Engineer Economy**—Usually three or four aircraft firms are asked to participate in the design study phase on a contract basis. By paying industry for this preliminary work, ARDC hopes to avoid the financial drain and waste of engineering man-hours imposed on the industry by former design competition methods.

By providing a relatively stable workload of development problems for the industry, ARDC hopes that individual firms will be able to keep their engineering teams intact even though they may be unsuccessful in a particular systems competition. The preliminary design study phase work will also help to keep the industrial groups up to date on the "state of the art" in military fields.

The responsible ARDC center takes the results of the industry studies, reviews and evaluates them to get a fix on what military capabilities can be achieved technically within the specified time limits. It uses data obtained from both industry and ARDC sources to make a more accurate forecast on the time required for the system development. The center then prepares a specific development plan for the system which includes:

Development Planning Objective

A development planning objective establishes qualitative guidance in broad terms for systems and techniques which will accomplish most efficiently USAF missions under probable future war conditions. A development planning objective results from the analysis and integration of the strategic, logistic and technological factors pertaining to each major combat and support mission of the Air Force. Primarily, development planning objectives will establish the broad analytical military mission base for the initiation of new developments at the systems level.

- **General design specification.** This is a blueprint for development of the system. It specifies the limits of the military capability that can be technically achieved within the time limits prescribed and it also defines the capabilities required of major sub-systems. It is evolved from the studies conducted by industry and ARDC centers.
- **Proposed development plan.** This details the new developments required to complete the system, the development timetable required to get all system components ready when needed, funds required to support development work, and a recommendation as to which of the contractors participating in the preliminary design study phase should be selected to develop the system.
- **Supporting resources.** This outlines the test facilities required by both the contractor and ARDC, flight test requirements, and the test equipment and peculiar skill requirements of the commands that will eventually test and operate the system.

Out of this development plan ARDC and the industry hope to get a complete and realistic solution to the military problem involved within a specific time period. The plan should tell what military capabilities can be achieved by the system, how long it will take to achieve them, and how much it will cost.

ARDC sends this complete development plan to USAF headquarters where it is reviewed by the Deputy Chief of Staff for Development and the Air Weapons Board and then comes up for a decision by the Air Council. If the Air Council decision is favorable the plan comes back to ARDC and is passed on to the responsible center where, in co-ordination with the Air Materiel Command, a Phase I development contract is awarded to a contractor to begin the system development.

The time cycle for this process from the publication of the GOR to award of a Phase 1 contract is about 11 months. The procedure was approved by USAF last October and the first industry design studies are due early this fall on a tactical bombing system. It will be at least five years before any weapons system developed under this process will appear in quantity with combat units.

▶ **Convair XB-58 First**—To increase the efficiency of weapons system development, ARDC is also buying industry's management ability in addition to its technical skill. This is handled by a single prime contract for a complete weapons system which fixes the responsibility for developing the system and integrating all its sub-systems into a combat-ready weapons system. First of these single prime contracts was awarded last spring to Convair for development of the XB-58 supersonic strategic bombing system.

Under the B-58 contract, Convair is not only responsible for developing the airframe of a supersonic bomber but is also charged with supervising development of virtually all other equipment required for the complete bombing system, including much of what was formerly government furnished equipment (GFE).

This additional equipment and major-sub-systems will be handled directly by contract between Convair and the component manufacturers instead of by separate contracts with USAF. Included in Convair's B-58 responsibilities are the following sub-systems: bombing and navigation, autopilot and controls, offensive armament, defensive armament; communications, reconnaissance; cooling; and ground support equipment.

▶ **Engines Separate**—The propulsion sub-system is exempt. ARDC feels that since modern engine development time and costs equal those of a large airframe, it cannot afford duplicate engine programs to meet the same power requirement in different weapons systems. For example, the time and cost of developing the P&WA J57 turbojet virtually equals that required for the Boeing B-52 bomber which it powers. Although the contractor will have considerable voice in the selection of propulsion systems for his weapons system, USAF through ARDC will make the final decision and handle development separately.

There has been considerable industry skepticism and opposition to the single prime contractor method. Some industry wags commented: "If that's the new USAF development philosophy, let them tell us where they want the bomb dropped and we'll do that too on a cost plus fixed fee contract."

Component manufacturers long used to doing business directly with USAF are uneasy about developing new sales relations with aircraft manufacturers and are fearful the prime contractors may expand to compete in their component fields. Present systems contracts specifically forbid the prime contractor to expand his physical facilities to do any component manufacturing and ARDC is watching the situation closely to prevent the component manufacturers' fears from being realized.

▶ **Effect on Prime Contractors**—ARDC will use the single prime contractor method only where a system development program requires it and a contractor appears to have the management and technical sources to handle it. If contractors decline to assume complete responsibility ARDC will act as the supervising authority.

It appears that aircraft firms interested in single prime contracts will have to expand their management resources and enlarge their technical staffs to develop competent evaluation teams for the major sub-system fields in which they will have to buy from competing component manufacturers.

▶ **Component Makers' Situation**—With the exception of an additional sales problem involved in selling prime contractors as well as USAF, there appears to be little change in the major components manufacturers situation under the new system. They will still deal with WADC laboratories and ARDC on the technical competence of their equipment and ARDC will retain a veto power over the prime contractor's decision on sub-systems.

If ARDC vetoes the prime contractor's selection of a subcontract source or equipment because of other USAF requirements, the sub system will be provided as GFE.

ARDC will assume responsibility for getting the system to meet the original requirements and the prime contractor will still be responsibile for integrating the sub-system into the weapon system.

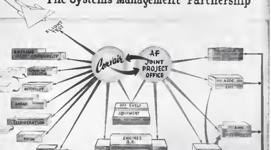
▶ **Working Together**—In order to make the new system work there must be a close relationship between the WADC laboratories, the prime contractor and the major sub-system manufacturers. An example of how this works is the B-58 bombing and navigation system. WADC labs helped Convair prepare performance specifications for the sub-system although the detailed specifications were written by Convair and proposals were solicited directly by Convair from the manufacturers in that field. These proposals were evaluated by Convair, with the assistance of WADC on technical matters and Air Materiel Command on logistical considerations.

After this process was completed, Convair picked Sperry to do the job which is being done under direct contract with Convair. ARDC encourages prime contractors to use the resources of both the WADC labs and the sub-system manufacturers in their preliminary design study work. On future proposals some prospective prime contractors are using the sub system manufacturers to help in the over all presentation to WADC.

The new system will not eliminate government furnished equipment. It will, however, restrict GFE more to standardized parts which can be used interchangeably in systems development. ARDC feels there is an acute need for an intensive campaign on standardized parts such as fasteners, bearings, vacuum tubes, etc., which can be used as interchangeable building blocks.

In these categories, where the third- and fourth-tier suppliers operate, no changes are anticipated. These suppliers will continue to get their products on the WADC approved list after passing lab tests and prime and sub-system contractors will use the WADC lists to pick their parts manufacturers.

▶ **Off the Merry-Go-Round**—The Joint Project Office System was established to give both USAF and the industry a single focal point for handling their mutual problems during the development cycle of new weapons systems. Earlier, the case of the contractor who talked with 72 USAF people in three days and still couldn't get a decision on his problem was by no means unique. One of the standard industry complaints was the amount of time its technical and management people wasted on the USAF merry-go-round.



The Systems Management Partnership

■ WEAPONS
AVIATION WEEK, August 17, 1953

The Joint Project Offices are physically located at Wright-Patterson AFB. They include representatives of both ARDC and AMC—combining the AMC buyer and the ARDC technical project officer in a single office with the authority to make decisions on projects within their bailiwick.

First JPO was established in August 1951 to handle the Boeing B-52 project. First dividends from the practice will be evident in the B 52 production program. Since then, the JPO have taken over a variety of projects, ranging from completely CFE-type aircraft already under development to the single-prime-contractor B 58 systems project.

The JPO expands as the project develops, beginning with as few as two people and reaching a maximum of more than 20 as the development cycle progresses. The B-47 JPO is now the largest at Wright-Patterson and has almost reached the proportions of an aircraft type branch. Size of the JPO declines as the development problems diminish. Command of the JPO also shifts during the cycle, with the ARDC office in control during the development phase and the AMC officer taking over as the production phase approaches.

▶ **Settling Conflicts**—Technical difficulties between the WADC labs and the JPOs are resolved by the Director of Laboratories and the head of the Weapons System Division. Conflicts between the technical and procurement viewpoints that can't be resolved in the JPO are handled first between Gen. Albert Boyd, WADC commander, and Gen. Walter Bain, AMC procurement director.

So far none have passed this level, but if necessary they can go to the level of Gen. Putt and Gen. Rawlings, ARDC and AMC commanders respectively, or beyond that to the USAF staff level, where they would be resolved by Gens. Craigie and Cook.

▶ **Improving Quality**—Although it is not directly related to the weapons system concept, the controlled production build-up appears destined to play an important role in getting better quality equipment on the aircraft industry production lines and reducing the time it takes to get combat-ready equipment to USAF squadrons. The plans call for an initially slow rate of production aimed at producing a relatively large quantity of aircraft for development testing and at the same time tooling up for quantity production. The requirements of development testing have long outgrown the three X models that were long the USAF standard, and now nearly 50 B 47s are engaged in development test work in support of that production program. By keeping initial production low, all of the major development work can be done on this test quantity with major modifications available to be fed directly into the production line when the signal is given to accelerate into quantity production.

▶ **"Bug" Blitz**—ARDC estimates that it now takes about 1,000 hours of flight testing to work about 90% of the inevitable "bugs" from a new fighter and about 1,800 hours to do the same job for a bomber. By doing the development testing before quantity production is begun, USAF hopes to avoid the costly post-production modification programs that have continually plagued its aircraft programs and postponed the time when equipment becomes combat ready. Among the specific postwar examples of these programs that have drained USAF procurement funds and prevented delivery of modern combat-ready equipment are:

- **A medium bomber** that has been in production for three years but was just recently pronounced combat ready by USAF. Modification program on bombers already built is about equal to original production costs.
- **A jet fighter** that went into quantity production with less than two hours experimental flight testing of its prototype. Structural failures were experienced in flight, killing a number of pilots, requiring an expensive, time-consuming modification program and leaving a large inventory of unusable spare parts.
- **A jet fighter** currently under test at Edwards AFB that requires extensive modifications for highspeed operations. Because the plane is already in production, nearly 300 aircraft will have been built before the modifications can be incorporated in the production line.

▶ **Production Speed-up**—By building the test quantity from production-type tooling instead of experimental tooling and proceeding with production tooling design and build up during the development test phase, USAF believes it can produce better planes in shorter time. The only gamble involved is the cost of the tooling committed during the development test cycle. If the decision was made to abandon production as a result of development tests the initial production tooling would be a total loss. If the decision to proceed with production is made considerable time will be gained.

The first aircraft to try the new system is the North American F-100 supersonic Sabre, but the first full-scale application of the plan will be on the Convair F-102 which is a radically new step in aircraft development.

▶ **Selling the System**—ARDC has been making a genuine effort to explain its new philosophy and procedures to the aircraft industry. Teams have briefed personnel of individual firms ranging from the board of directors down to engineering groups and ARDC played host to a conference of industry leaders in Baltimore last January to exchange ideas of mutual problems.

Naturally there are still some skeptics among the major aircraft managements who are reluctant to alter their traditional business methods and there is active opposition in some segments of the component manufacturing industry. ARDC still has an educational and sales job to accomplish on its industry relations.

But there are many people in the aircraft industry who are encouraged by the vigor and freshness of ARDC's approach to some of the longtime USAF development problems. Both the industry and the rest of the Air Force will be observing closely the progress of these new methods an attempting to evaluate the degree of improvement they bring on the major problems that have long hampered USAF weapons development.

General Design Specification

A general design specification is a statement of the limits of **military capability** that can be **technically achieved** in the time period prescribed and applies to the entire weapon system. It will define the **capability** of the **major sub-systems** that combine to make the system a **complete** operational entity. The general design specification is evolved from studies fixing the probable state of exploratory research and development within a specified time, including a complete review of the state of all applicable existing and projected component developments. The details will be of sufficient technical description of the possible military capability to permit determination whether the existing applicable exploratory research and development can be employed or new developments will be required, resulting in later availability.

Development Plan

The development plan, including the general design specification, is a schedule of the development and test phases of the system proposed as a solution. It contains realistic estimates of the funds, logistics, personnel, training, and other supporting requirements necessary to the planned systems developmental and operational objectives.

OSR: Keystone of Basic Research

- **Weapons of tomorrow need research today.**
- **This office monitors, supports such study.**

Baltimore—The men who monitor curiosity in the Air Force sit in the Office of Scientific Research at Headquarters, ARDC.

Across their desks pass contracts and reports on shock tubes, the chemistry of hydrazine, high-frequency ultrasonics, problems in global geometry.

The common denominator of all these subjects is curiosity, the key that has opened door after door in man's search for knowledge. Curiosity leads to questioning and eventual understanding; and in the words of the scientific axiom, "If you understand the problem, it's already half solved."

▶ **Search for Understanding**—OSR's job is to promote understanding; its policy is to advance fundamental knowledge through basic research in fields of science where there is a reasonable expectation of eventual use by the Air Force. In carrying out this job, OSR spends about six million dollars out of the 560 million total that the Air Force spends in both applied and basic research.

Chief of Scientific Research for the Air Force is Col. Oliver G. Haywood, Jr., West Point graduate and DSc. from Massachusetts Institute of Technology. He reports directly to the Commanding General, ARDC, at an organizational level that reflects the importance of basic research in the Command.

▶ **Now for Later**—OSR was established in November 1951 in recognition that air superiority in the future is dependent upon adequate basic research in the present.

The office approaches its mission in two ways:

- **It acts as general supervisor** over all research under way at the nine major Centers of ARDC.
- **It supports directly a program of basic** research in universities, foundations and industrial laboratories.

The total list of projects numbers about 200, with about 175 different investigators or teams doing the work. A few of these contracts are with foreign universities, where the technical competence for special problems is available. But the bulk of the Air Force's basic research program is placed in the universities and colleges of the United States.

▶ **Definitions**—It is no easy task to define the term "basic research." It means many things to many people. But in the Air Force, basic research is best defined by a chart which Haywood credits to Dr. Ralph Gibson of the Applied Physics Laboratory, John Hopkins University.

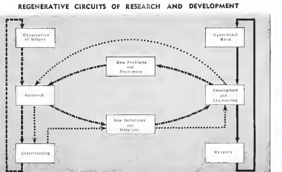
The chart—called "The Regenerative Circuits of Research and Development"—shows the continuous cycling of observation, fact and result and the way those three feed back into the closed loops of R&D.

In its left-hand circuit, the chart pictures "pure" research, in the right hand circuit, it pictures the engineering loop.

Basic research in the Air Force arises in the dotted cycle that ties these two extreme processes together.

▶ **How It Works**—It works this way. A research scientist will be curious about some difficulties in the Air Force development program. These difficulties may arise because of a general lack of understanding of the underlying physical phenomena involved. So the scientist begins research, not directed at a specific solution, but rather toward

REGENERATIVE CIRCUITS OF RESEARCH AND DEVELOPMENT



the development of basic understanding

We expect that this understanding will help us in our development programs," says Haywood

▶ **Examples**—As one example, OSR monitors a large number of contracts for mathematical investigations Several of these are in topology, the study of space characteristics that are changed only by tearing or joining, and not by deformation

"This field may seem far removed from the Air Force. Actually Dr. von Neumann developed his famous theory of strategic decision on the basis of considerations from abstract mathematics, such as topology," said Haywood

Another broad example is in combustion. Fire has been used for eons, but the basics of flames are not yet understood. OSR sponsors six projects in the chemical kinetics of combustion, aimed at understanding the fundamental process of a reaction that has been working for and against man for centuries

▶ **Covering the Field**—Here are some OSR projects that are being undertaken in other fields

• **What holds atoms together in a molecule?** An OSR contract at Duke University under Dr. Gordy is seeking the answer to this question. One of their laboratory tools is radar, usually thought of only as a distant-detection device, but here working on a submicroscopic level

• **What is the boundary layer?** Dr. Francis Clauser, at Johns Hopkins, is working with extremely thick boundary layers in a windtunnel His studies have evolved a dimensionless parameter which—like Reynolds number for free-stream flow—is characteristic of the boundary layer.

• **Can a computer replace a human interpreter?** Dr. Perry, of MIT, has made mathematical explorations of a digital computer to translate Russian into English.

▶ **Seven Fields**—Basic research interest in the Air Force falls into seven major categories

• **Chemistry.** The composition, structure, properties and transformation of matter; energy production, photographic chemistry, principles and theories necessary in guiding exploratory programs

• **Fluid mechanics.** Boundary layer, turbulence, compressibility and viscosity effects, aerothermodynamics and rarefied gas problems.

• **Mathematics.** Algebra, statistics, probability, analysis, topology, geometry, computational methods and high-speed computers.

• **Solid State Sciences.** Structure of special crystals, extreme temperature studies, surface physics, structure and properties of solids.

• **Physics.** Theoretical and quantum mechanics, atomic structure, spectroscopy, optics, magnetics, electricity, heat, radiation, sound instrumentation and nuclear physics

• **Bio-Sciences.** Biology, psychology, aviation medicine, anthropology, sociology, physiology, biophysics, biochemistry, radiobiology, aerobiology, entomology and parasitology.

• **Geophysics.** Physics of the solid earth and its atmosphere, including geodesy, geomagnetism, seismology, meteorology and atmospheric physics at all levels

▶ **Policies**—No research is done by Haywood's office; the entire program is contracted, mostly to universities

Programs are initiated generally by a university. Encouraged to keep OSR informed of special qualifications in one or more of the fields of Air Force research interest, the university can best speak for itself in measuring its ability to perform a task.

In rare cases, OSR may give prominent men in a certain field where there has been little activity. One of these is photographic chemistry, where according to Dr. Horner, OSR's chief of chemistry, there has been little done in the development of emulsions since the beginning of photography

▶ **Contract Requirements**—Every contract monitored by OSR has been let on a "sole source" basis, and justified on that basis. There are four major requirements which must be met by the investigator

• **Research must be in an area of Air Force interest**

• **Investigator must be qualified to do the work proposed.**

• **Research should be scientifically significant—worth publication in any of the top-flight professional journals.**

• **Institution must be contractually sound.**

▶ **Small Teams**—More than half the OSR contracts are for less than $20,000. The OSR wants to continue this situation, and to avoid the "brute strength" method of applied research where large teams work toward a single goal.

After the studies have been made, OSR encourages publication of the unclassified results—almost all work is in that category—in scientific journals. Going a step beyond usual AF procedures, OSR will accept a manuscript copy, as submitted for publication to a professional journal, instead of the conventional final project report.

The contracts written by OSR normally cover one and one-half to two years of work, because the Office wants to maintain some stability in the program. "Research cannot be turned on and off like a faucet," says Haywood.

"We want scientists who can devote the bulk of their time to research, and not research administration,' he added Normally it is expected that the scientist who is designated as principal investigator in the contract will spend at least 25% of his time on the particular project

▶ **Who Benefits?**—The policies of the Office of Scientific Research are aimed at providing the maximum benefit to the nation, the Air Force and the universities The value to the nation and the Air Force of a strong research and development program is apparent

The universities are enriched in a number of ways. Financially, of course, through payments to students and research workers for their efforts, and through purchase of equipment and supplies which would otherwise not be available The publication of reports adds prestige to the university, and may aid in attracting the type of scientific workers needed in its research

The OSR program also adds to the normal research load which is the traditional task of the university and an essential part of its graduate education program

▶ **Duplication**—Haywood emphasizes that the Air Force has the greatest incentive to avoid unintentional duplication. One of the ways to do this is to keep information current in the field about its programs.

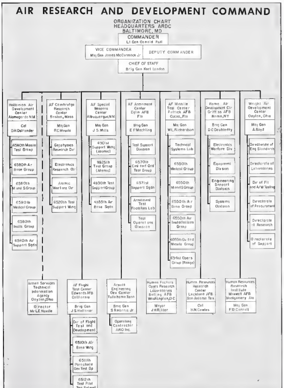
There is an OSR record book kept current on a monthly basis which tells who is doing what research and how much it is costing Interested government offices, such as NACA, the National Science Foundation, Office of Naval Research and Office of Ordnance Research, have copies of the book There are other formal and informal channels, the service research officers exchange copies of programs and proposals under study

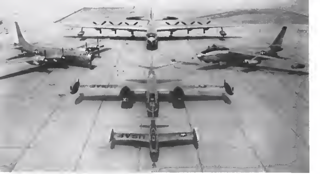
Haywood, in answering proponents of a single center for all government-sponsored research to avoid "waste and duplication" says, "It is difficult to select the geniuses of the future Let us continue to bring to this problem, not the talents, techniques, procedures and motivation of one organization, but rather the decentralized judgments that are the true strength of democracy"

▶ **Submitting the Proposal**—Proposals for research in the first five fields listed above (chemistry, fluid mechanics, mathematics, solid state sciences, physics) should be submitted to the Commanding General, Air Research and Development Command, Attn RDR, P O Box 1395, Baltimore 3, Md

Proposals for basic research in the biosciences should be marked for the attention of RDDH

Proposals in geophysics should be submitted to the Commanding General, Air Force Cambridge Research Center, 230 Albany Street, Cambridge 39, Mass





USAF atomic warfare capability is represented by these five aircraft ranging from a fighter to intercontinental bomber

Atomic Weapons Work

USAF expansion of atomic warfare capabilities is sparked by development and test work done by men and aircraft of ARDC Special Weapons Center at Kirtland Air Force Base. ARDC activities support Atomic Energy Commission on Nevada Proving Grounds and at Eniwetok Overseas Proving Grounds.

TECHNICIANS decontaminate Thunderjet radiological safety plane

B-29 is checked for radiation with ion counter.

Center Mates Planes to Atom Weapons

Special Weapons Center's job is to match AEC's new atomic developments and the AF planes that will have to deliver them.

By Robert Hotz

Albuquerque, N. M.—A new family of atomic weapons is being mated to a new generation of supersonic aircraft and missiles by the Special Weapons Center of the Air Research and Development Command.

Located on a mile-high, sun-baked mesa overlooking the Rio Grande, the Special Weapons Center (SWC) at Kirtland Air Force Base is part of the New Mexican atomic triangle that includes the Atomic Energy Commission laboratories at Los Alamos.

This atomic triangle is guarded by the 34th Air Division of the Air Defense Command, which maintains F-86 Sabres on constant alert. A radar net carefully scans the area and rigid air discipline is enforced.

▶ **Atomic Weapons Bridge**—The principal job of the Center is to bridge the gap that exists between the Atomic Energy Commission and the Air Force and to match the atomic weapons developed by AEC with the aircraft and missiles developed by USAF.

AEC is charged with the responsibility of research and development on atomic and other "special weapons"—but it has no aircraft or missiles to develop or test delivery methods.

USAF is charged with the primary responsibility for delivery of AEC's weapons and it has control over the research and development of the atomic delivery vehicles.

As the chief liaison between the atomic development agency (AEC) and the atomic delivery agency (USAF), the Special Weapons Center is playing an increasingly important role in shaping the future of military air power.

▶ **New Factors**—Keys to the current nature of the Center's work are recent disclosures by the Atomic Energy Commission on the increasing production and variety of atomic weapons. Both the production and variety have exceeded original estimates. These facts are radically altering the traditional concept of air power in the atomic age.

"The prevailing tendency has been to think of the atomic weapon exclusively as a weapon to be used only against the largest and most expensive type of target," says Maj. Gen. John Mills, Center commander. "But new designs of atomic weapons are being developed to further our capability to permit economical use of atomic weapons against a much wider variety of targets. Because of the Atomic Energy Commission's development of a 'family of atomic weapons' the Air Force can now deliver varied kinds of atomic weapons against varied targets with varied aircraft types.

"Looking forward from the Hiroshima and Nagasaki era of eight years ago, the technological progress of the Atomic Energy Commission and the Air Force in the atomic weapons program is remarkable in the approach to universality."

▶ **Atomic Carriers**—This variety of atomic weapons and its influence on the rapidly expanding capability of USAF to wage atomic warfare can be gauged partially by the variety of aircraft that have already been modified and equipped by the Special Weapons Center to deliver atomic weapons. They are:

• **Boeing B-47 Stratojet bomber.** This six-jet bomber is the fastest bomber now in service with combat units of any Air Force. B-47s of the Strategic Air Command fully loaded recently have crossed the Atlantic to England in little more than four hours.

• **Convair B-36 intercontinental bomber.** This 400,000-lb. aircraft powered by six piston engines and four turbojets has demonstrated its ability to fly more than 10,000 miles and drop an atomic bomb load at the halfway point.

• **North American B-45 Tornado bomber.** This four-jet bomber was the first jet bomber to drop atomic weapons. A Tactical Air Command B-45 wing was the first jet bomber unit to be equipped for the waging of atomic warfare.

• **Boeing B-50 Superfortress.** The B-50 equipped for aerial refueling has combat capabilities almost as great as the B-36 and made an important addition to the long-range atomic striking force of SAC in the interim before large-scale production of jet bombers provided the modern equipment for atomic warfare.

• **Republic F-84G Thunderjet fighter.** Although the F-84G is a rapidly obsolescing first-line fighter aircraft, the fact

Maj. Gen. John Stewart Mills, Commander, Air Force Special Weapons Center ... won the Silver Star, Distinguished Flying Cross, Air Medal, Presidential Citation and the French Croix de Guerre for combat operations leading the 450th Heavy bombardment group in the Mediterranean Theater of Operations ... born in Appleton, Wis. 1906 ... graduated U. S. Military Academy 1928 ... served in bombers for six prewar years ... was chief of AMC's instrument and navigation unit at Wright Field ... after World War II served a hitch as deputy chief of the War Department General Staff's new weapons division ... named assistant for atomic energy at USAF Hq. in 1949 after his graduation from the National War College.

JET DRONE with empty cockpit and mother plane roar down runway for takeoff.

JET formation sweeps toward atomic cloud.

DRONE carrying mice and monkeys leads T-33 mother ships and pair of F 86 chase planes that will destroy drone if controls fail.

■ KIRTLAND

that atomic weapons have been developed that can be carried by fighter-type aircraft marks a revolutionary trend in atomic air warfare It is a concrete indication of what the increasing variety of atomic weapons will mean to military air power. In recent testimony before the Senate Foreign Relations Committee (AVIATION WEEK Apr 7, p 9), Gen Alfred Gruenther, commander of the NATO forces in Europe, said the key NATO strategy was now based on the use of atomic bomb-carrying F-84Gs (standard NATO air force fighter bomber) against enemy ground force concentrations

► **Planes Take Longer**—Experience has proved it takes much longer to develop a new aircraft or missile with atomic capabilities than it does to develop new atomic weapons Currently atomic weapon development is outstripping technological progress in development of the weapon's delivery system

Center officers feel strongly the need for a longer range and more stable research and development program for the development of atomic weapons delivery systems Unless some methods are found to keep the research and development program from reacting violently to the annual congressional budget cycle fluctuations Some observers feel the gap between the atomic stockpile and the capability to deliver it swiftly and certainly to enemy targets will widen

"Atomic bombs in a stockpile won't win a war," said one Center officer long associated with the atomic program. "We must have a fast, guaranteed method of delivery The new atomic weapons are coming along faster than the means of delivering them.

"A stable research and development program would permit more long-range planning to develop the best type of vehicle for new type weapons when both are in the early planning stage If we could do this it would eventually save many millions of dollars later by eliminating the need for expensive modification programs to try to tailor available vehicles to the new weapons."

► **"Cranking" Them In**—One of the important jobs of the Center now is to analyze the designs of all new USAF aircraft and missiles proposed or under development to determine their atomic capabilities. Similarly, new aircraft rolling off the production lines will go to the Center at an early stage for development of atomic capabilities An early production Boeing B-52 Stratofortress eight-jet bomber is earmarked for the Special Weapons Center and the 10,000 ft main runway at Kirtland will have to be widened to accommodate the outrigger landing gear of the B-52

It is also reasonable to suppose that the new generation of USAF supersonic fighters now coming along will be "cranked in" to the atomic capability already displayed by the F-84G Among these likely new prospects in expanding both the scope and delivery speed of USAF atomic capability are the swept-wing F-84F Thunderstreak, now in production at Republic's Long Island plant, the North American F-100, now flying in prototype form at Edwards AFB, and the McDonnell F-101 long range escort and penetration fighter

Early Days

The Special Weapons Center originated and developed into its present size and status as a result of the Air Force's growing postwar responsibilities for the delivery of atomic weapons In 1947 Gen Curtis LeMay then director of Air Force research and development and now commander of the Strategic Air Command, sent Maj Gen Howard Bunker to Albuquerque to establish a field liaison office with the Atomic Energy Commission aimed at developing USAF knowledge of the AEC weapons program in order to aid USAF in planning and executing its atomic mission

► **Transmission Belt**—Primary mission of this field office for atomic energy was to act as a transmission belt of detailed information between AEC and USAF, to keep both agencies informed on the other's progress and problems in the atomic weapons development and delivery

Kirtland AFB was then an Air Materiel Command base, but headquarters of USAF wanted direct control of the field office so it was assigned merely as a tenant on the AMC base In December 1949 the Special Weapons Command with Gen Bunker in command was activated at Kirtland to succeed the field office

Under command status the organization got better people and improved facilities but its primary mission was still liaison with AEC, the Los Alamos and Sandia laboratories

This group kept the Air Force informed on atomic weapons development and transmitted USAF requirements and problems to the AEC technicians who were working on weapons development

► **Assigned to ARDC**—Late in 1951 the remarkable progress in both quantity and variety of atomic weapons created an acute need for an expansion of the Command's mission to include some types of research, considerable development and an expansion of the test work in support of AEC. Because the Special Weapons Command was not a part of ARDC it was precluded from doing development work, so Gen Mills, who succeeded Gen Bunker as commander, proposed that the Command become a part of ARDC and take on the badly needed development program.

Keeping pace with the expanding USAF atomic capability, the Center now has about 5,000 personnel and a high percentage of all aircraft assigned to ARDC It ranks second to Wright Air Development Center in spending ARDC research and development funds

Current Center activities involve research, development and test work. Most of the Center's work is absorbed by test support operations for the AEC both for the Nevada proving grounds and the Eniwetok overseas proving grounds

"BEEPER" pilot with control equipment.

LOCKHEED QF-80 equipped with atomic cloud sampling tanks on both wingtips.

"GUNK" SPRAY washes radioactive debris from drone cloud sampler.

RADIOLOGICAL safety men check tanks with ion counter

KIRTLAND PLANES track this grey atomic cloud as it sweeps eastward after nuclear test blast on Nevada Proving Grounds.

Research

All of the research done at the Center is applied research aimed at solutions to particular problems. The Research Directorate at the Center has no laboratories, farms out most of its work to industry and universities. Its principal product is paper—reports and analyses for the guidance of USAF. It is a job requiring a high degree of technical competence for USAF officers involved and 70% of the personnel assigned have advanced degrees ranging up to doctorates in nuclear physics.

▶ **Research Program**—Research activities fall roughly into three categories.

- **Providing "state of the art"** information from the field on atomic weapons programs to USAF policy makers.
- **Conducting technical analytical** studies for guidance of USAF in developing the best weapons systems with which to conduct atomic warfare. These studies are extremely broad and include such factors as potential enemy opposition, delivery capabilities and potency of the weapons against specific types of targets.
- **Conducting technical training** program for USAF personnel in Atomic Energy Commission facilities to build up an adequate technical experience level among USAF personnel who are required for work in the special weapons fields, both in the research and development program and also with operational commands that use atomic weapons, such as Strategic Air Command and Tactical Air Command.

USAF personnel with proper education backgrounds are picked to work for 2- to 3-year assignments in AEC establishments in regular technical staff jobs. Some of the top people now in special weapons work, such as Col. Lester Woodward, chief of the research directorate at the Center, who has a doctor's degree in nuclear physics, have worked in the Los Alamos laboratory detached from USAF for several years. This technical training program is regarded as an extremely valuable feature of the Center's work in building up USAF atomic capability.

▶ **Link With Cambridge**—There is a coordinating link between the Special Weapons Center and the Cambridge Air Force Research Center which has recently established a division of atomic warfare staffed largely with veterans of the SWC.

Close liaison is also maintained with the atomic and armament directorates and weapons system offices in ARDC headquarters.

Development

Just as the research program produces primarily paper, so the development program produces primarily hardware. The development mission began in 1952 after the Special Weapons Command became an ARDC center.

It is aimed at designing and development equipment capable of delivering atomic weapons and includes both aircraft and missiles. Col. Harry Dorricht, who headed the development program until his recent appointment to command of the 4925th Test Group

Atomic Force Role

"The principal deterrent to another world war is and will remain the offensive strength of our constantly improving atomic weapons and our ability to deliver them with accuracy and certainty by strategic air power against the sources of Soviet military might.

"Unless and until peaceful Soviet actions are assured on a lasting basis, we must constantly maintain and improve our ability to strike through the air with devastating atomic force at the air bases and munitions factories of any aggressor nation."

—**James Harold Doolittle, special assistant on technical matters to the Chief of Staff, U. S. Air Force.**

(Atomic), emphasizes that atomic armament poses more problems of greater complexity in handling, carrying and delivering than other older types.

Part of the development mission also involves detailing USAF requirements for atomic delivery systems, defining problems to be solved and then presenting them to the aircraft industry for mechanical solutions. The Center technicians feel strongly that the aircraft industry is the best laboratory in which to do this kind of development work.

▶ **To Reduce Modifications**—Other jobs include the development of standardized specifications and testing, monitoring and handling equipment for atomic weapons. There is still a good deal of actual aircraft modification required in the development mission since early postwar USAF aircraft were not specifically designed around atomic capabilities. In order to cram early-type atomic bombs into the bomb bay of an early jet bomber a section had to be removed from the main wing spar.

It is now a center responsibility to review all USAF aircraft and missile designs from the earliest stage of their development. As more atomic capability is designed into these vehicles there will be a diminishing need for extensive and expensive modifications to build in atomic capabilities belatedly.

The development group works closely with the AEC Sandia laboratory and the operational commands who have the final responsibility for delivery of atomic weapons.

Test & Support

Bulk of the Special Weapons Center's resources are devoted to test work. Most of the test work is in support of the Atomic Energy Commission, although other test functions are performed for the Defense Department, Chemical Warfare Service, Army Ordnance and other ARDC centers. The center supports both AEC atomic proving grounds—the continental site in Nevada and the overseas operation at Eniwetok Atoll in the Pacific.

▶ **Test Missions**—During the AEC test operations the 4925th Test Group (Atomic) performs the following missions:

- **Dropping the bomb** or nuclear test device.
- **Providing flying laboratories** to gather airborne data on results.
- **Providing cloud sampling** aircraft. The cloud sampling aircraft are both piloted and pilotless. B-29s and F-84s have been equipped with sampling devices and have actually been flown through atomic clouds by properly protected crews. Lockheed QF-80 jet drones are also used equipped with Sperry remote control flight systems. The drones are controlled from mother planes aloft, and in recent tests flew monkeys and mice through atomic blast clouds at 30,000 ft. T-33s also are equipped with cloud sampling equipment which is carried in place of wing tanks.
- **Providing radiological safety** aircraft. These planes measure airborne radioactivity in the area of nuclear blasts and ground activity in the Nevada Proving Grounds where "fall out" from the atomic cloud usually occurs.
- **Cloud tracking aircraft.** These aircraft track the atomic cloud as it moves eastward on prevailing winds and measure its radioactivity and radioactive fall-out to warn aircraft and civilian inhabitants on the ground in case of heavy fall-out. The atomic clouds travel eastward across the country and dissipate over the Atlantic. There is seldom any radioactive fall-out from air bursts, but this phenomenon occurs with more intensity in ground detonations since heavy earth particles are drawn up into the atomic cloud.
- **Terrain survey helicopters.** These helicopters cover the terrain surrounding a nuclear blast and chart safe approach areas to instrumentation, test equipment and damage sites.

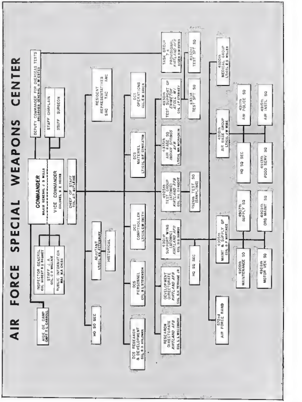
▶ **Precision Bombing & Timing**—The USAF atomic test group has dropped 17 of the atomic bombs and nuclear test devices that have been exploded by the U. S. in Japan and in continental and overseas test operations.

Air drop is considerably cheaper than a ground detonation, but to be truly effective for test purposes it must have an accuracy within 100 yards and be detonated within two seconds of a predetermined time. Attaining this accuracy is a precise team operation on the part of the air crew that comes only with long training in the special atomic delivery techniques.

Here is a rough idea how the crew of a 4925th B-50 made a drop on the Nevada proving range from 33,000 ft. that hit within 200 ft. of the target within the two-second time margin. (Key to this precision is the ability of pilots to fly exact and stable courses and make perfect precision turns, and the skill of the bombardiers using both visual and radar equipment to plan and execute the mission exactly.)

▶ **Typical Drop**—The pilot and co-pilot split the flying duties to obtain greater precision and stability. Pilot controls the attitude and airspeed of the aircraft

SPECIAL WEAPONS CENTER technicians use chemical spray to wash radioactivity from cloud sampling plane, note sampling devices.



with normal flight controls while the co pilot controls altitude with the throttles Just before the bomb burst the pilot flips on dark glasses leaving the co pilot flying the aircraft on instruments. When the bomb detonates the co-pilot is temporarily blinded and the pilot takes over behind his dark glasses

The radar bombardier navigates most of the mission from his spot in the B-50's rear compartment A radius-of action problem is used to set up the bomb drop but a time pattern is flown instead of a ground pattern to cancel any instrument errors The radar navigator also furnishes the radio operator with precise position reports that are broadcast to other aircraft in the vicinity and the test control center He computes wind drift and acts as a clearing house for winds-aloft reports from other aircraft He positions the aircraft for the target run where the visual bombardier takes over After the bomb release, the radar navigator has the final task of giving the crew a count-down to the burst, warning them to take proper safety measures

The visual bombardier guides the aircraft during the actual bomb run and releases the bomb In the B 50 a Norden bombsight of World War II vintage was used Three special equipment officers were carried in the crew Their job was to install and operate the special instrumentation required by AEC. A flight engineer, radio operator and two mechanic scanners completed the crew On this atomic drop the crew reported they could feel the heat and blast effects at 33,000 ft. and the B 50 was "tossed about a little" by the shock All crews flying in the area of atomic blasts are equipped with dosimeters to warn of excessive radiation

▶ **Support Aircraft**—The Center operates the Indian Springs air base near Las Vegas for air support of the Nevada proving ground missions It draws on aircraft from other services and commands to supplement its specialized fleet to test operations. During the Nevada tests in the spring of 1953, formations of SAC B-36 and B-47 bombers flew over the bomb bursts to give their crews familiarization with the environment of an atomic attack Navy has also provided some piston-powered Douglas Skyraider and Grumman Bearcat drones for cloud testing, and MATS and SAC provide specially equipped transport aircraft

When supporting overseas tests at Eniwetok, the role of the test group is the same except that instead of controlling all air operations it operates as part of a joint Army-Navy-USAF task force

Like all of the ARDC centers, the Special Weapons Center has its problems Personnel is an acute problem.

Because of the strict security nature of the special weapons work, the personnel problem extends down to the airman level For example a truck driver who has been security-cleared and trained to handle nuclear weapons is still listed as just a truck driver in military personnel classifications When he is transferred away from the Special Weapons Center he is replaced with an ordinary truck driver who has to be cleared and trained before he can drive the particular kind of trucks at Kirtland

For officer personnel, the first year of their duty tour at Kirtland is usually required for indoctrination. A longer tour of duty in this specialized work would produce better results, personnel experts believe

Since Kirtland AFB had been abandoned after World War II, it was necessary to completely rehabilitate the field and its surrounding installations for Special Weapons Center work The intensive training requirements and the extensive hardware modification work of the Atomic Test Group made a new building program necessary which is still not complete or adequate

Because atomic warfare is a top priority mission of USAF the work of the Special Weapons Center in developing better atomic delivery vehicles and training personnel in better atomic delivery techniques is a top priority mission for the Air Research and Development Command A good deal of the future of the Air Force and the future of this country depends on how well the Center does its job

Col Daniel Hooks
Vice-Commander

Col Benjamin Holzman
Director of R&D

Col Harry Donicht
Commander, 4925th Test Group

Col Lester Woodward
Director of Research

TODAY'S TESTS begin near this memorial to the Wright brothers, located on a hilltop near the site of their early test flights.

ANECHOIC ROOM is silent cell for calibration of communication equipment.

TEST CELL is sealed for high altitude simulation.

WADC: $200-Million Research Key

Wright tackles its biggest job: tying together Air Force research to produce the supersonic weapons of tomorrow.

By Alexander McSurely

Dayton, Ohio—Wright Air Development Center, with 12 sprawling laboratories for research and testing and its flight testing facilities, is a sturdy corner stone for the Air Research and Development Command that is building the new air weapons system for the U. S. Air Force.

Few people, even among the specialist employes assigned at the big Wright center itself, have a clear picture of the wide variety of interrelated projects which go churning through this big research and development mill. Its history is being written daily in hundreds of pages of technical reports, photographs, oscillograph records, and other recording devices.

But hidden in this vast accumulation of technical data is a fascinating story of some of the steps that must be taken between the drawing board and the complete weapons system that goes whistling through the stratosphere at supersonic velocity carrying its deadly missile under the sensitive control of an intricate electronic guidance system.

▶ **Toughest Assignment**—This $200 million concentration of aeronautical research and testing equipment, spread over a 1,325-acre tract in the Mad River valley east of Dayton, is tackling its toughest assignment in the long years of its aviation development history.

The assignment: to administer and coordinate new aeronautical research with electronic and armament research so the Air Force will have progressively better new supersonic weapons capable of achieving their combat missions at speeds and efficiencies far beyond those already being achieved.

▶ **Outside Help**—The enormous scope of this research and development job inevitably means calling upon industry and educational institutions to carry a large share of the load. WADC's laboratory men have a double job. While continuing an impressive list of research projects themselves, they are busy too as coordinators of outside work, directing research by contract for tangible use in new air weapons of tomorrow.

Contracts with industry, universities and non profit organizations now represent 87% of the total WADC budget. And WADC's procurement directorate spends more than 75 cents of every Air Force research dollar. These contracts represent many hundreds of projects, assigned to 130 colleges and universities, in addition to large portions of the routine testing work farmed out to commercial laboratories and manufacturers.

▶ **Two Phases**—Actually the center's job breaks down into two assignments:

- **To procure and produce** advanced aeronautical scientific knowledge as rapidly as possible for tangible use in new air weapons.
- **To monitor** from a technical standpoint (through testing and evaluation) each new weapons system from earliest stage to obsolescence.

Maj. Gen. Al Boyd, commander of the center, expresses the overall idea in these simple words:

"The work we do today will definitely determine the security of this country five or 10 years from now."

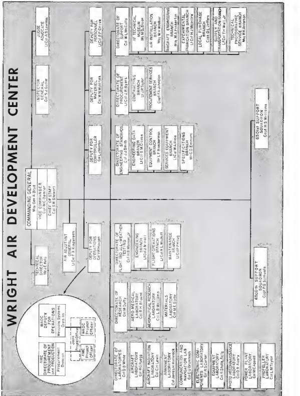
▶ **Center Layout**—To understand best the way WADC functions, a knowledge of the geographical layout helps.

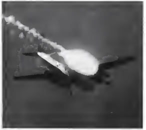
- **Area B.** The center headquarters and the laboratories and test facilities are concentrated in what is called Area B of Wright-Patterson AFB. The principal U. S. Army and Air Force aviation development and testing work has been centered in this same area since 1927, when it was opened under the name of Wright Field.

Up until the transfer of Air Research and Development Command head-

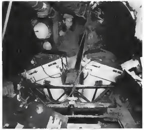
TECHNICIAN installs combustion can on J47 during overhaul preceding tests.

GLOBES AND TUBES calibrate fuel flowmeters.





HELLROARER is new continuous light source for night photography.



SPLIT VERTICAL test installation of cameras in NAA RB-45

quarters to Baltimore three years ago this area was also the site of command headquarters. It continues to be the largest single installation of the command, from a standpoint of personnel and value of equipment, although three of the other centers, the flight test centers for planes and missiles, are larger in acreage.

■ **Area C**. Supplementing the Area B installations are the facilities across Springfield Pike, known as Area C of the Wright-Patterson base, where the Directorate of Flight and All Weather Testing does its test flying from a 10,000 ft. runway.

Part of Area C is used by the Directorate of Support which does maintenance and special modifications for test on from 150 to 200 planes flowing through the center for special flight tests. The tests are sometimes basic to the aircraft itself, and sometimes they are carried out on equipment that is flown in the airplane.

▶ **To Get There**—Once you are in downtown Dayton, it's simple to get to "Wright Field," as most Daytonians still call it.

Drive east on either First Street or Third Street. Both streets run into Springfield Pike, and you continue east on this main highway (Route 4) until you see the flying field on your right, with the windtunnels and test buildings behind it on the hill.

If you have further business at the flight test directorate, get an Area C stamp on your pass at the Area B pass office, and continue about 4 mi. farther east on Route 4, past the big Air Materiel Command headquarters building on your left, until you come to another main gate on the left which will pass you into Area C.

▶ **Important to Taxpayer**—The terrific costs involved in today's high speed military air weapons make it necessary for the Air Force to see quite clearly where it is going on each of its new investments before it is too late to change plans.

That is why the laboratory and flight testing work here at WADC and at the other ARDC centers, and all the outside research and development contracts, represent a solid investment, even if some of the projects never prove out.

It is far cheaper to have a failure and find it out by thorough testing at an early stage, and discard it, than to carry it through to production, and then find it out.

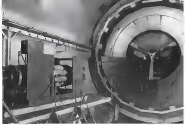
Thus you can readily understand how a nickel's worth of research and testing can and does save the taxpayer many a dollar by insuring that something is right before it is ordered into production.

▶ **Weapons System Division**—In order to put more emphasis on the new weapons system concept in development, WADC is organized with its operating deputy charged with directing the weapons system division. Every other organization in the center, including the laboratories, is keyed in to help this division in the performance of its function.

How the weapons system division operates—through project officers assigned to each project who work cooperatively with counterpart project officers assigned by Air Materiel Command procurement division—is detailed elsewhere in this issue.

Maj. Gen. Albert Boyd, Commander, Wright Air Development Center ... veteran USAF test pilot ... one of the first USAF pilots to fly faster than sound in the Bell X-1 ... recently evaluated British and French fighter aircraft for purchase under U. S. offshore procurement program ... born Rankin, Tenn., 1906, grew up in Asheville, N. C. ... learned to fly as aviation cadet, Kelly Field, 1929 ... served in engineering jobs in Air Service Command ... went to Europe as Deputy Commander Eighth Air Force Service Command supporting General Doolittle's Eighth Air Force combat units ... returned to U. S. as chief of Flight Test Division, Air Materiel Command, at Wright Field ... commanded Air Force Flight Test Center at Edwards, Calif., 1949-51 ... awarded Distinguished Flying Cross.

WOOL streamers show wing, tank flow pattern



JET ENGINE blasts against prop undergoing simulated flight vibration test

■ WRIGHT

But it is important to realize that the various research and development projects, both those of the laboratories and of the outside contractors, have as their ultimate goal the creation of new improved weapons systems through this division

▶ **Six Directorates**—An organization chart of WADC shows six directorates, plus the several deputies and officers who operate directly on the commanding general's staff

This review of the center is more concerned with the directorates of laboratories, of research, of flight and all-weather testing, than with the supporting directorates of engineering standards, procurement, and support. However, it is obvious that these three last-named directorates perform indispensable functions when the overall picture is taken into consideration

■ **Directorate of research** includes three laboratories, all concerned with long-range research and serving as consultants on trends in development of weapons systems. These are organized according to scientific areas of research. Their products are research reports which can be applied to solve general problems relating to weapons systems and their components. However, the work of some of these overlaps with that more directly associated with end item products. The three research laboratories are the aero medical laboratory, the aeronautical research laboratory, and the materials laboratory.

■ **Directorate of laboratories** includes nine laboratories concerned with development of actual hardware, and with applied research to carry out definitely scheduled developments. These include laboratories specializing in aircraft, aircraft radiation, aircraft armament, communications and navigation, electronic components for aircraft, aircraft equipment, photo reconnaissance, power plants, and propellers.

Probably the best way to understand the Wright Patterson story is to take a look into the laboratories and watch some of the research and testing as it goes on

Aircraft Lab

Some of the most spectacular and elaborate testing equipment at WADC includes the six windtunnels and the huge structures test building assigned to the aircraft laboratory

This laboratory has the assignment of evaluating, studying and testing airframes of USAF planes and missiles to improve them aerodynamically, structurally and dynamically. The aircraft engineers also serve as technical consultants on aircraft and missile designs, translate results of their research and study into specifications and design criteria for use by manufacturers, and work to increase the range and performance of aircraft and missiles

Col. M. C. Demler, Vice Commander

▶ **One of a Kind**—Unduplicated in the U S and possibly in the world are facilities of the structures building, which is equipped with overhead cranes with capacities up to 300,000 lb. It has a big enough clear space so structures tests could be run on the XB-36 in one piece. "We had to take it in sideways," one of the structures laboratory chiefs explains

The tests involve applying static loads on complete airframes or on assemblies such as wings and tail surfaces

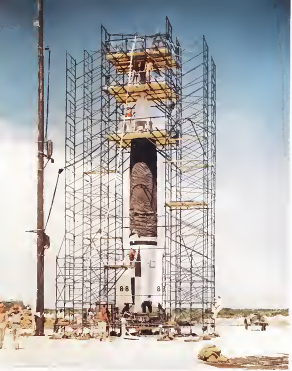
▶ **"Whiffletree" System**—The principal method uses a neoprene tension patch cemented to the structure to be tested. Hydraulic cylinders apply the desired load through a metal plate cemented to the outside of the patch, and the result is a close simulation of the actual flight load which that part of the plane may have to take

The patch system is sometimes called the "whiffletree" system because of the resemblance of the linkage to the familiar method of hitching a horse to a cart.

Development of this system goes back to 1938, when E. R. Weaver, veteran civilian engineer, and Col Paul Kemmer, lab chief, were credited with developing it to replace the old loading practice of using shot bags. Although the shot bags are still used on some tests, the neoprene patch system has spread to virtually all major U S aircraft plants

A fairly recent refinement of the system, credited to industry development, involves placing under the patch a vinylite blanket which is evacuated with a vacuum pump to increase the tension

On a recent day in the structures lab, you could see simultaneously undergoing such tests the North American F-86H (improved Sabrejet) and two

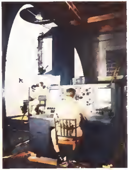


BUMPER RESEARCH ROCKET readied at Cape Canaveral launching site for horizontal flight of second-stage of WAC.

ARDC CENTERS' RESEARCH WORK

MARTIN MATADOR pilotless bomber takes off with rocket booster from zero-left field-type launcher at Cape Canaveral.

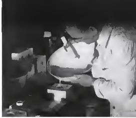
ROCKET TESTING at Edwards AFB



NEW AVIONIC GUNNERY TRAINER checks bomber crewmen.

RYAN TARGET DRONE is checked before launching at Holloman AFB

SUPERSONIC PROP model is checked on highspeed stand before tunnel testing



CERAMICS are compounded for high heat use

versions of the Northrop F-89 Scorpion jet night fighter—the F-89C and F-89D.

▶ **Hot Tests**—Interesting example of how the problems are multiplying as requirements become increasingly severe is the attention now being focused on structures tests at high temperatures (similar to those that are beginning to be encountered due to highspeed friction).

The problems involve distribution of the heat over the airframe to represent different temperatures and to reproduce thermal shock due to rapid change in temperature in a structure which may be hot on the exterior and still cold inside.

Temperature changes as rapid as 10 deg./sec. are considered commonplace. Preliminary tests with heat ovens indicate that some other means of structures tests in which the heat will be applied locally probably will be required.

Corollary problems involve development of a new method of applying the loads at high temperatures, with materials that can withstand the temperatures better than the neoprene or shotbags.

▶ **Movable Walls**—Movable test chamber walls and welded steel windtunnel blades are innovations which the aircraft laboratory windtunnels are putting into use to get more out of their present facilities.

The moveable walls of the 10-ft. transonic tunnel can be expanded or contracted by operation of hydraulic jacks to provide subsonic or supersonic airflow under the same power conditions. (The further expansion of the air permitted by the larger opening creates higher speeds.)

The WADC tunnel uses a ventilated test section developed from work by National Advisory Committee for Aeronautics for its transonic windtunnels. So WADC engineers feel their tunnel is at least as good as any other transonic tunnel today. It operates at Mach numbers up to 1.24 with good flow characteristics at stagnation pressures up to 1½ atmospheres. Pressures of 2 atmospheres may be used at slightly lower Mach numbers.

▶ **Completion Cut Off**—Here is an example how cutoffs in research funds have slowed development. A new supersonic windtunnel, with a 24-in. throat, designed for speeds of Mach 1.5 to 2.3, is 90% completed. But it will not be able to go into operation without additional funds to operate it.

Although it is believed that the tunnel could be completed and put into operation cheaper than equivalent windtunnel time could be purchased elsewhere, this project has remained virtually in "suspended animation" since an economy decision by the Department of Defense McNarney committee two years ago.

John E. Keto,
Technical Director

▶ **Other Tunnels**—A smaller 6-in. section supersonic tunnel, built as a scale model for the 24-in. tunnel, has been pressed into actual use and has produced some excellent data. It now is being reworked to step up its top speed from Mach 2.75 to Mach 3.

Rounding out the WADC tunnel complement are the 20-ft. tunnel, capable of 400 mph. windspeeds, the 12-ft. vertical spin tunnel, one of two in the U. S., and the old but still useful 5 ft. windtunnel in the lowspeed range, which dates back to old McCook Field.

▶ **Available to Manufacturers**—Any military contractor can windtunnel-test his new aircraft design in any of the WADC tunnels, if it is scheduled by the weapons system division.

Most models tested are provided by the manufacturers and are built with such painstaking attention to detail that costs run as high as $80,000 for a single unit. Models up to a maximum of 14-ft. span can be tested in the 20-ft. tunnel.

Data from the tunnel tests is obtained through tiny pressure orifices on the surface of the models, with as many as 300 orifices and 300 pressure tubes on a single model. Recording is done automatically by an International Business Machine printer and cardpunch. A computations unit reduces the data, by taking 10% of the cards, but a complete record remains available if needed. A teleplotter machine which plots eight curves at once, is another automatic aid.

It takes about two to three weeks to complete an average test, although a complete windtunnel evaluation in a single tiedown configuration may run as long as two months.

▶ **Every Plane**—One goal of the aircraft laboratory is to spin test every fighter and trainer before it is flown. It is felt that there is still no way to predict mathematically or empirically the spin characteristics of an aircraft and the

only way to pin this down is by the spin tunnel technique

A restriction against intentional spinning of a plane should be the last resort, only after other modifications for improving spin recovery characteristics are thoroughly tested.

▶ Design Branch—Probably the most unpublished group of engineers in WADC are the members of the preliminary design group in the aircraft laboratory. It is their task to prepare various alternate designs of aircraft and missiles based on the state of the art as it is expected to be five to 10 years hence.

They must put together design information from every available source into designs that will guide the Air Force planners on performance that expected aerodynamic and propulsive advancements will be able to provide.

Their estimates are a major basis for the formulation of actual Air Force requirements for future weapons systems, so the accuracy of their future projections is very important to the success of the weapons systems.

▶ Various Approaches—"We never make a finite recommendation that one configuration is the answer but we study the whole field and show various capabilities with different approaches to the problem," one of the engineers explained.

Models of enormous 500,000-lb.-gross weight aircraft—dwarfing even the Convair XC-99, largest of today's planes—and a galaxy of model configurations, many of which are like nothing flying, can be seen in this branch. In some of the older models, however you can trace many proposed innovations in design just now appearing in some of our latest aircraft.

▶ Mechanical Branch—Powerful inertia brake testing machines which simulate landing speeds up to 200 mph. with tire loads up to 316,990 lb. give airplane wheel, brake and tire assemblies a rugged proving in another aircraft laboratory installation.

As a sample of experimental development, one tire tested here is designed for 325-lb. pressure. Its 5½-in. tread heats to 400F at contact.

This mechanical branch also conducts increasingly important tests on hydraulic, pneumatic and mechanical actuating systems and their components.

▶ Special Projects—Development of a wide range of miscellaneous projects necessary for successful operation of weapons systems—from aircraft emergency escape systems, down to cowl fasteners and rivets, pressure sealing of cabins, and integral fuel tanks—is the assignment of a special projects branch in the aircraft laboratory.

A complete laboratory unit within this branch, for example, is assigned to research and testing on bearings, considered one of the most critical problems in modern aircraft. This includes not only the jet engine bearings, which determine the actual life of an engine, but bearings on which aircraft flight controls operate, and many other types of bearings.

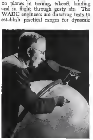
Here you will see odd Rube Goldberg-type machines turning and turning, wearing out specimen bearings of chromium, vanadium steel, cobalt steel, ceramics and other materials. The bearings are tested for friction, for oxidation, for heated conditions, and are checked during the tests with special optical, electronic and mechanical gages.

One prized piece of equipment in this laboratory is a rare Zeiss interference microscope which magnifies 680 times. It is one of three in the U.S.

▶ Aerodynamics and Dynamics—The two other principal branches of the aircraft laboratory are concerned with the application of newly gained aerodynamic knowledge in improving flight characteristics from the standpoints of lift, drag, and stability. They work closely with the windtunnel and structures branches.

Problems of flutter—the unstable oscillation of a wing or tail surface which can build up until it destroys the aircraft—which has been a designer's bugaboo for many years, are still being studied here. Theoretical methods have been developed to predict flutter in subsonic speed ranges, but they are not yet adequate for the new aeroelastic and dynamic problems found in the transonic and supersonic speeds.

Important too in dynamic research is the study of excessive loads imposed on planes in taxiing, takeoff, landing and in flight through gusty air. The WADC engineers are directing tests to establish practical ranges for dynamic loads in these conditions for specific aircraft.



GLOBE recorder for simulated navigation.

▶ Many Contributions—The aircraft laboratory looks back on many contributions which its own engineers and industry engineers under its project direction have made to advance the aeronautical art.

Some contributions the lab claims:

- First stressed-skin aluminum wing.
- First investigation of rocket assist for takeoff.
- Pioneering in spin testing and development of the first spin recovery parachute.
- Pioneering in pressurization of aircraft cabins.
- Pioneering in flight testing for flutter, and in dynamic simulation of flutter on aircraft models.
- Development of vibration-isolating engine mountings for radial engine and propeller combinations to isolate the vibrating impulses of the engine from the aircraft.
- Pioneering in recording vibration in aircraft structures in flight.
- Pioneering in development of magnesium as an aircraft wing material.
- Pioneering in the field of windtunnel instrumentation, including the development of digital converters on recorders.

Powerplants Lab

The American aircraft engine industry is best qualified to do the actual design fabrication and development of aircraft propulsion. This is the policy that governs the WADC powerplant laboratory. The lab, however, reserves to itself the task of guiding and evaluating the manufacturers' development efforts and solution of powerplant problems developing in field operations.

▶ Eight Types—Today the laboratory is working with eight types of powerplants, plus several hybrid combinations of the basic types. These include turboprop, turbojet, piston, ducted fan, ramjet, pulsejet, rocket and atomic power. Each type has its own problems in fuels, lubricants, installations, power transmission, ignition, starting, etc.

Development branches assigned to direct the programs in these fields include:

- Rotating engine branch for piston and turbine engines, starters and helicopter transmission systems.
- Non-rotating engine branch.
- Nuclear propulsion branch.
- Accessories branch.
- Installation branch.
- Fuels and oil branch.

▶ Test Facilities—To monitor the development work of the powerplant industry, the laboratory operates engine test facilities for sea level calibration, and endurance and simulated high-altitude tests. These facilities are among the largest and most varied in the world.

Turbojet engine tests stands are capable of testing engines up to 40,000-lb. thrust at sea level, or about four times the power of today's operational turbojets. Ramjet test facilities can test a small ramjet at Mach 4 at simulated altitudes in the neighborhood of 100,000 ft. under either free jet or direct-connect conditions.

Technical problems involved in simulating the extreme altitudes and temperatures have required huge refrigeration and air conditioning systems for the stands.

Other test facilities provide for qualification test and environmental test of such items as fuel metering and control devices, ignition, engine accessories, fuels and lubricants, and components of fuel and lubrication systems including lines, seals and tanks.

One example of the test requirements is a new air preheater recently installed for ramjet tests which feeds air into the engine at 1,200F simulating temperatures encountered at Mach 4 speeds.

Rocket test facilities operated at WADC are supplemented by the large rocket engine test facilities operated at Edwards AFB, and the laboratory also works closely with other ARDC facilities for flight test of aircraft and missiles on powerplant problems.

► **Engineering Fixes**—The familiar Air Force "UR" system of unsatisfactory reports for engines comes home to the powerplant laboratory, where each case of a malfunction is referred to the branch responsible for its development.

In the powerplant teardown and machine shop section, you can see a wide variety of engines, actually called in from the field for examination and engineering fixes on specific problems. It is a costly way to trouble-shoot, but it pays substantial dividends in positive fixes.

► **Achievements**—While much of today's work is under security wraps, some idea of the part the powerplants laboratory is playing in the aircraft propulsion picture is found in study of some of the past developments in which the laboratory engineers have played important roles.

Basic patents on some of the most important features of today's power plants are held by former and present staff engineers. Some of these developments include:

- First internally cooled exhaust valve for piston engines.
- Sponsorship of the turbosupercharger.
- Sponsorship of high-octane-rating aviation gasoline.
- Invention of the oil dilution system for starting engines at low temperatures.
- Early work on singlepoint refueling, and on water injection for aircraft engines.
- Basic work on high-temperature coolants for liquid-cooled engines.
- Early work on individual cylinder fuel injection.
- Early recognition of the importance of more powerful turbojet engines at a time when 1,500-lb.-thrust engines were considered sufficient.

Flight and All-Weather

At 45,000 ft. over a tiny island in Lake Erie, a sweptwing North American F-86 Sabre jet fighter noses down into a roaring highspeed dive in an attempt to aim the shockwave which the dive creates at another F-86 circling the island below.

Pilots of both planes are Wright Air Development Center test pilots, studying the little known phenomenon of shock waves and their effects on objects they strike. They are graduates of the Air Force Test Pilots School at Edwards AFB, Calif., and every test flight they fly is a carefully pre-planned checkout of the airplane and/or the equipment it carries, under some special condition of flight.

► **All-Weather Tests**—Since the concept of developing an all-weather air force was adopted, the Air Force has entered a new phase of flight testing, which becomes Phase V—all-weather flying—in the rigorous program which a new airplane must experience. This phase is carried out from the air base at Area C of Wright-Patterson AFB, by WADC's Directorate of Flight and All-Weather Testing.

In addition to the Phase V tests for all new airplanes, the pilots are called to fly many other project flights, testing new equipment and doing special research such as the shock wave experiments.

Currently about 150 Air Force airplanes are assigned to the Area C flight test hangars, and until recently the number was up to 200. As many as 15 Boeing B-47s have been at the base for the last year, undergoing tests related to various equipment changes and fixes, including ejection seats, drag parachutes and inflight refueling.

Col. S. R. Stewart, Chief of Staff

A check of one test pilot's log showed that he had flown tests on the following planes in the last month: B-36, B-47, B-29, B-50, B-17, B-26, and B-45, for a total of 61 flight hours.

► **Flight Refueling**—Some of WADC's bomber branch test pilots have recently made flight refueling tests of the new Boeing prototype KB-47 jet tanker with a B-47 receiver plane, and other recent tests have been made with a Convair B-36 bomber outfitted as a tanker, using both the flying boom and probe-and-drogue methods of refueling.

Example of how routine the probe-and-drogue system is becoming is found in the story of a Navy jet pilot who asked for a checkout and ran up a score of 36 connects and disconnects during a flight between Dayton and Columbus, although it was his first aerial refueling experience.

In the refueling equipment tests, the WADC pilots take the tanker and receiver planes through specified speed and altitude conditions checking out the equipment at intervals throughout this range. A jet T-33 chase plane usually accompanies the fueling tests for photographic coverage of the procedure.

► **Powerplant Test**—A fighter test pilot cited one of his unusual assignments—a flight test with a Lockheed F-94C nightfighter powered with a Pratt & Whitney J48 engine with afterburner. This particular test involved testing the temperatures in all of the combustion chambers in flight by recordings from temperature probes in each burner can.

► **Weather Variety**—The varied weather found in the Miami River valley, and the valleys of its tributaries, makes the Wright-Patterson base an ideal location for the Phase V all-weather testing. Objective of this phase is to test the ability of the aircraft to fly under adverse weather conditions, and to develop special recommendations, if necessary, for instrument and night flight operation.

Missions are flown day and night, under a variety of ceilings and visibilities, in icing and turbulent conditions. Local flights are monitored by ground radar.

Data from the flight is compiled into a comprehensive evaluation of the plane's all-weather capabilities. This data becomes the basis for operating instructions furnished with the service airplanes, outlining techniques to be used by combat pilots under instrument conditions from takeoff to land-

ing, including recommended airspeeds and power settings

Many of the pilots are on assignment at manufacturers' plants, or on special arctic or tropic tests several months of the year

▶ **Atomic Tests**—One told how he flew the XB-47 out of the Bikini atomic tests two years ago and made a little-known emergency landing with a drag chute on an abandoned 4,400 ft runway on a Pacific island which had been a Japanese airstrip during World War II

Three crews from the WADC flight test organization flew B-50 and B-29 planes in more recent atomic tests

▶ **Maintenance Crews**—To keep the test planes flying, a maintenance organization of 700 persons is assigned at Area C These men also handle special installations, working with laboratory technicians responsible for the equipment installed

Aera Research Lab

In a test building at Wright Air Development Center, a model of a nose wheel landing gear is running through a series of tests aimed at eliminating the undesirable "shimmy" characteristics which have wrecked a number of Air Force planes, including a Northrop XB-49 jet flying wing and a Fairchild C-119 cargo transport

These tests are being conducted simultaneously with contract investigations at Cornell laboratory, at Fairchild at Hagerstown, and at Bendix Aviation at South Bend, on actual aircraft

▶ **Computers Too**—Meanwhile, the aeronautical research laboratory at WADC is running mathematical problems, involving all the parameters being tested in the actual tests, through its computers The computation branch can make about 100 test runs to each actual run made on the model

This is an example of the investigations being carried on by the Aero Research Lab Its task is to examine special problems, such as the landing gear stability problem, affecting a wide range of aircraft, and determine a general practical solution which can be applied as an advancement in the aeronautical art

▶ **Playing the Field**—The newest of WADC's 12 laboratories "plays the field" in a systematic scanning of the entire physical science horizon, area by area, looking for new and better concepts, techniques, and materials to apply to improvements in air weapons

Its scientists work in project teams Of its projects, 75.3% are under contract to outside organizations with specialized equipment and apparatus or with specialized technical skills Byproducts of many of the projects, useful commercially rather than militarily, are made available to industry for commercial development

▶ **Computer Research**—Through mathematical computation, the laboratory has found faster and cheaper means to study aerodynamic characteristics of modern air vehicles The new methods are about 75 times faster than previous methods, and one-tenth as costly Using the prodigious "memory" capacity of large digital computers such as a new General Electric "brain" recently installed at the laboratory, extremely long sequences of mathematical operation can be run off with rapidity

Some of the investigations that have already been made mathematically include:

- **Study of vibrations** in delta wing airplanes and in propellers
- **Analysis of the escape of** crew members from highspeed aircraft
- **Analysis of parachute opening shock**
- **Investigations of flow** in ducts and windtunnels
- **Analysis of breaking strength** of materials

▶ **Incalculable Aid**—The value of the computers in speeding the reduction of research data obtained in windtunnels and other testing equipment is probably incalculable

Before the installation of these machines, a backlog of data existed on such problems as flutter analysis, design parameters for autopilots, bombing systems, propeller control systems, fire control systems, and equations of motion of aircraft in complicated maneuvers such as rolling and pullup

Now the electronic machines are rapidly overcoming this time lag between tests and data application

Interesting byproduct of the computing research technique is a small lightweight automatic data reduction computer for airplane installation This is designed to reduce complex flight test programs to simple answers.

Other computing machines have been designed for demonstrating results of various war strategies, and for solving complex logistic problems

Propeller Lab

Research facilities of Wright Air Development Center's propeller laboratory are not duplicated in the U S and probably not in the world Therefore WADC does electric whirl-testing of propellers and helicopter rotors for Navy aircraft as well as for Air Force

▶ **Supersonic Props**—Development contracts with the principal propeller manufacturers for new types of turbine props to provide thrust for supersonic airplanes have been followed up since mid World War II days

The laboratory's persistence in this field, even when some Air Force policy trends were calling for bypassing the propeller completely, is now beginning to pay off Flight tests have begun on a McDonnell XF-88B Voodoo twin-jet fighter which has been modified to carry a turbine turning a small supersonic thin-blade propeller in its nose This work is proceeding under a development contract sponsored by the propeller laboratory Several other supersonic propeller developments are close to flight test stage

▶ **Rotor Rig**—Meanwhile the first large-dia. rotor blades for the new Piasecki XH-16 helicopter recently have been delivered for whirl-testing on the laboratory's rotor tower

The tower accommodates 95 ft-dia rotors, and has a 4,000-hp motor to whirl rotors at from 150 to 600 rpm at a 50-ft altitude, duplicating conditions in flight above or at the top of ground cushion

▶ **Prop Testers**—Most powerful propeller whirl rig, now being completed will be powered by a 30,000 hp motor Used with adapters, it will be capable of testing jet and turboprop engine compressors, as well as propellers It will be able to turn these rotating elements at speeds up to 12,000 rpm and develop up to 150,000 lb thrust

Other propeller engine test stands are provided with capacity for running engines rated as high as 8,000 hp In addition, one of the 40 ft dia stands is being modified to accommodate turbine engines up to 15,000 shp

▶ **Other Devices**—Other interesting equipment at the propeller lab includes

- **Fatigue testing** equipment for vibratory fatigue testing of rotor blade sections up to 10 ft long and 28 in. wide under tension loads up to 100,000 lb
- **Radio noise suppression** equipment for study of propeller radio interference
- **Experimental prop and rotor** shops for assembly and modification of units for tests
- **Propeller control testing** equipment for studying propeller hubs in temperatures of minus 97F and for vibration strain gage testing

One interesting method of testing involves a propeller rig with the blades whirled in the blast from the tailpipe of General Electric J47 jet engine The blast and the use of baffles make it possible to put the blades of the propeller through a complete cycle of loaded and unloaded condition once for every revolution of the prop

Equipment Lab

The research and development work of the equipment laboratory leads all other groups at WADC in both number and diversity of projects It is responsible for 276 different classes of equipment items, which amount to 21.5% of all the specifications for items used by the Air Force

Principal subdivisions include:

- **Ground servicing equipment** for aircraft.
- **Electrical equipment**, both airborne and ground
- **Instruments**, ranging from flight control and engine to meteorological units, telemetering systems, radiological, biological and chemical detection instruments, and warning signal instrumentation, together with accessories, mounting, lighting, etc
- **Maintenance and support** ground equipment, including fire fighting vehicles, hoists, aircraft jacks, towing vehicles, etc
- **Mechanical equipment for de-icing,** heating, cooling, pressurization, cargo handling in the aircraft
- **Parachutes** for personnel, cargo and deceleration of aircraft
- **Airborne lifeboats** and other rescue equipment
- **Training** equipment, ranging from elaborate flight simulators of specific airplanes, to aerial tow targets

▶ **Climatic Tests**—To test the operation of various equipment items under severe conditions similar to some they may encounter in flight, the laboratory has an extensive array of test equipment This includes a battery of climatic condition chambers for simulating virtually any condition that can be encountered in aircraft operation any place in the world

Some of these specialized cells will simulate salt fog for corrosion tests; sand and dust equivalent to the severest sandstorms known in nature; humidity, sun and rain alternately; extreme dryness with only 5% humidity or less; fungus growth in warm moist conditions, and high-altitude conditions up to 150,000 ft levels

▶ **Centrifugal Forces**—In other tests, equipment is exposed to terrific centrifugal forces by whirling in centrifuge machines Two of these machines are used One will spin a 25-lb piece of equipment with up to 100 times the force of gravity, or a 100-lb item at up to 25G

A typical item under test in this centrifuge was an automatic parachute opening device, operating on an aneroid barometric pressure principle

A larger centrifuge will subject equipment weighing up to 2,000 lb to centrifugal forces equivalent to 40G This includes an arrangement by which a second rotational force can be operated inside the orbit of the main rotation, so that the equipment can be exposed to two rotational forces simultaneously

▶ **New Instrument**—Example of the complex specialized instruments under development as the result of higher speeds is a new type indicator to show indicated airspeed, Mach number and true airspeed, all on the same dial

The instrument is provided in two sizes—the larger is scheduled for installation in the Boeing B 52 eight jet bomber, and the smaller for installation in the F 101 jet fighter

Indicated airspeed covers range of 80 to 650 knots, Mach number range is from 0 5 to 2 2, true airspeed range is 150 to 900 knots The indicator will operate over an altitude range of zero to 80,000 ft.

A remote computing mechanism actuates a servomechanism to indicate the true airspeed on a Veeder style counter on the dial A remote altitude sensitive mechanism actuates the Mach number scale, while the same pointer shows indicated airspeed on a fixed dial, and Mach number on a moving scale

▶ **De-Icer Sprayer**—An example of special ground equipment developed is a de-icing sprayer, winterized to operate at temperatures down to minus 65F It quickly removes frost and ice from parked aircraft by spraying them with chemical de-icing compounds Device includes a high lift platform rising to 50 ft , from this ground crews can now reach the most inaccessible exterior surfaces of the largest aircraft in service

Photo Recon Lab

To insure that aerial photography for intelligence keeps pace with the new higher speeds and altitudes of today's and tomorrow's aircraft is a mission which has brought today's air photography a long way from World War II days Even then it was estimated that aerial photography provided 80% of the intelligence material actually found useful

Night operations of the Reds in Korea have been successfully exposed by USAF's night aerial photography. Illumination has come from huge photoflash bombs that provide sufficient light for good photographs from as high as 40,000 ft and flash cartridges each providing over 100 million candlepower for use in low altitude highspeed photographic runs

▶ **New Equipment**—Two new stabilized camera mounts, developed as projects of the photo reconnaissance laboratory at Wright Air Development Center, are being accepted by the Corps of Engineers as superior to previous stabilized mounts, for accurate mapping photography

One uses a gyro-stabilization principle and the other handles the camera as part of the armature of a large motor, moving it by windings similar to those of an electrical motor field

▶ **In Rockets and Missiles**—Excellent performance has already been given by cameras carried in rockets, and camera equipment is being designed for missile and robot aircraft installations

Materials Laboratory

New information about titanium alloys, wrapped up in a collection of 70 equilibrium diagrams that show graphically how the alloys react at various temperatures, is being made available to the U. S aircraft industry.

Prepared by Armour Research Institute under contract to Wright Air Development Center, the diagrams make possible a selection of the best alloys from this group for possible aircraft alloy materials.

▶ **Titanium Alloy**—Next step is for industry, under experimental contracts, to make engine components—such as compressor blades—from these alloys.

Goal of this avenue of development and testing is the development of titanium alloys with satisfactory properties for use under the higher temperatures and loading conditions in the new regime of powerplants for supersonic flight operations.

▶ **WADC Projects**—The titanium research is but one phase of a large number of materials development and testing projects directed by the materials laboratory at WADC. These are some others

- **Service tests** recently were completed on a high iron content alloy identified as U-912, which lasted longer under severe conditions than the presently accepted jet turbine bucket alloy S-816.
- **Molybdenum** tests are continuing with promise for very high temperature applications. But the metal is susceptible to oxidation. Efforts to correct this drawback are under way.
- **Recently developed** aluminum casting alloy, which has better properties at 600F than any other known aluminum casting alloy, is being evaluated for possible use in the Curtiss-Wright J65 Sapphire engine. It is identified as ML-alloy.
- **Powdered magnesium** alloy recently developed is considered to have extrusion and forging properties far superior to those of current commercial magnesium alloys.
- **Plastics research** is centering now on high-temperature structural plastics of silicone and polyester types for extended operation at 500F as an outgrowth of development of phenolic type plastics, which can operate for short intervals in such temperatures. The plastics are used for various aircraft and missile components.
- **Rubber development** centers on synthetics with special properties of resistance to fuel, oil, acid, water and extremes of temperature but maintaining good elongation strength and abrasion resistance. Among developments in these fields are the sheathing material of polyvinyl chloride rubber for wires and cables in today's airplanes and hose used for air-to-air refueling.

SABRE with special flight test boom.

Flight Test Center Probes Aviation's Supersonic Frontiers

by William Coughlin

Edwards, Calif.—Near the center of the Mojave Desert, less than 100 mi. northeast of Los Angeles, lies a huge, level expanse of hard-baked clay and silt known as Rogers Dry Lake. Its glistening surface, 13 mi. long and 5 mi. wide, throws off a blinding glare under the hot sun and occasional sandstorms swirl across the dry bed.

Located on the western "shore" of this lake is Edwards AFB. Here, the Air Force Flight Test Center sits in judgment on the aircraft products of the Air Research and Development Command.

Its diverse facilities sprawl over 200,000 desert acres to make Edwards the second largest Air Force base in the U. S., exceeded only by Eglin in Florida.

Without Rogers Lake, Edwards would not exist. For 10 months of the year, the lake is dry and its fine clay and silt surface can support pressures up to 250 lbs. per square inch. A fully loaded B-47 can land without making a wheel mark.

▶ **Concrete Tabletop**—"Hard as concrete and flat as a tabletop," is the way Brig. Gen. J. Stanley Holtoner, commanding officer of Edwards, describes the 65-sq. mi. surface which is used for flight testing.

The story of Edwards is a story of supersonic research craft thundering across the lakebed like strange mirages and of the world's top test pilots and scientists laboring in desert isolation to push back the frontiers of aerodynamics.

It is a story of research and testing under adverse conditions, with sand sifting through rundown wartime buildings to foul delicate avionics equipment, with facilities so crowded one contractor uses an abandoned boiler room for office space, and with a former lavatory serving as locker room for some of the nation's best military test pilots stationed here.

▶ **Roll of Fame**—The pilot roster includes civilians like Bill Bridgeman, who flew the D-558 II to a record speed of 1,238 mph. and a height of better than 79,000 ft.—"where I could see the curvature of the earth"—and military men such as Maj. Charles E. Yeager, first man to fly an airplane faster than sound.

Here took place what Gen. Hoyt S. Vandenberg called the greatest aeronautical achievement since the first flight of the Wright Brothers—the flight of the rocket-powered X-1 through the sonic barrier.

Here is rising a permanent national military flight test center based on a $120 million master plan nearing one third completion—but which could become what one officer calls "monuments in the desert" if threatened cuts in research and development funds halt its construction.

▶ **Nature's Work**—But it is the lake which dominates the base. "Without it, the type of experimental flight testing we do would be impossible," says Lt. Col. William D. Brady, chief of the Plans, Programs and Operations Div.

Rogers Lake is a drainage basin for much of the Mojave Desert and gentle rains cover it with up to 18 in. of water in the winter. Desert winds sweep this water back and forth during the rainy season, annually resurfacing the lakebed with a natural action which prompts Gen. Holtoner to call Nature "our best contractor."

Laid out on the lake's surface are several runways more than 5 mi. long and one runway with a length of 8 mi. Only runways such as these could accommodate aircraft like the X-3, which requires a takeoff run of 3 mi. before its stubby straight wings can carry it to supersonic speeds. The hard lake surface also provides the distance needed for highspeed dead-stick landings of rocket-propelled research aircraft.

HVAR rockets roar from Sabre suspended to simulate flight conditions.

PROTECTIVE clothing is required for crew fueling supersonic XF-91 experimental fighter from alcohol-oxygen refueling truck

▶ **Plane-Saving Length**—In addition, expensive test aircraft many times have made emergency landings on the broad expanse. Republic's XF-91 made seven emergency landings on the dry lake during its test program. Only aircraft of its type built, its loss would have washed out the test program and seriously delayed development of Republic's F-103 supersonic fighter.

A running total maintained by the flight test center shows an estimated $218,246,629 worth of aircraft saved by the lake since Apr. 4, 1946. This figure is not total value of the aircraft involved but merely an estimate of amount of damage that would have been done had the dry lake not been available.

▶ **Clear and Open**—Other important factors also influenced the decision to locate AFFTC here. Weather while hot is so clear that flight testing is possible 350 days of the year.

The remote location not only affords security desirable for highly classified projects but avoids dangers inherent in testing experimental aircraft over populated areas. Closest town of any size, Lancaster, is 30 mi. distant.

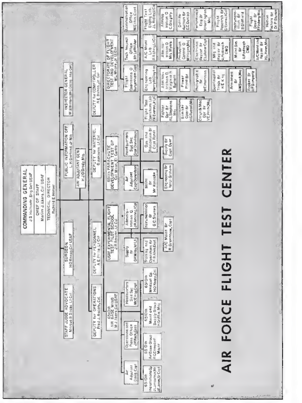
Yet in spite of its desert isolation, Edwards is close enough to Southern California aircraft production centers to bring the men testing new aircraft in close liaison with the designers and technicians who build them. North American Aviation, for example, operates up to 10 flights a day for its specialists traveling between Edwards and the home plant at Los Angeles International Airport.

The location is well summed up by Al Carder, head of Douglas Aircraft's testing unit, when he says: "The good Lord had highspeed aircraft in mind when he put that lakebed out here."

▶ **Varied Projects**—Edwards AFB, where the complete air weapons package is tested for the first time in its development cycle, is one of the most versatile installations in the Air Force. AFFTC flight tests all USAF aircraft, engines and components as well as Army aircraft. About 90% of its testing is done at the request of Wright Air Development Center.

Edwards also operates a number of special test facilities and the base is shared with other government agencies and almost all major Air Force contractors. Work being done by these contractors often is for the Navy.

Such varied projects may be under-



BOEING B-47 STRATOJET ROARS past Joshua trees on takeoff from Rogers dry lake bed for special ballistics mission

way simultaneously as flight testing of Navy's XF4D and XA3D, Army's H-25 and L-23, Boeing's B-47E, North American's YF 100, Republic's F-84F, Douglas' X-3, Lockheed's F-94C and Fairchild's C 119.

Commanding officer of the test center, Gen Holtoner, not only is responsible for flight testing but also for the Experimental Flight Test Pilot School, the base wing organization, and ARDC's parachute test facility at El Centro, half an hour's jet ride to the south. Technical director of the center is Richard E. Horner.

Test Facilities

Special test facilities include

- **Rocket engine test station,** 20 mi. east of the main base, where static thrust facilities are provided for testing of extremely high-thrust guided missile rocket engines. The test station is operated by ARDC almost entirely for use by contractors.
- **Highspeed track** (10,000 ft. long) where supersonic sleds, pushed along by rockets at better than 1,000 mph., test seat ejection, parachute brakes and such aircraft components as tail sections.
- **Deceleration track** (2,000 ft. long) located on the northwest shore of the lake in "Agony Gulch," where human volunteers and animals are slammed into jolting braking systems to simulate G forces received in aircraft crashes.
- **All-altitude speed course,** consisting of three ILS radio beams set sideways to form perpendicular planes to the line of flight, enabling accurate speed measurements through the course at any altitude.
- **Precision bombing range,** operated by the Aberdeen Bombing Mission (ABM) of U S Army to compile bomb trajectory data used in Air Force bombing tables. Study of a new family of bomb shapes currently is underway with the B 36, B-47 and B 45.
- **Photo theodolite grid,** for the study of time and distance relationships during the takeoff and landing of aircraft. This installation photographs aircraft through a grid which makes possible measurement of distance required for landing or takeoff roll, climbs and descents, and acceleration or deceleration.
- **Photo range for night test dropping** of flash bombs and checking the accuracy of new photo-reconnaissance equipment.
- **Radar facility for tracking** and recording flight test data, such as air speed during either diving maneuvers

Brig. Gen J Stanley Holtoner, commander, Air Force Flight Test Center ... has flown every type of Air Force fighter from the P-1 to the F 86 ... more than 60% of his 5,500 flying hours are in fighter aircraft ... specialist in aerial gunnery tactics ... commanded 82nd Fighter Group in Italy in World War II ... awarded Distinguished Flying Cross ... born in New York City, 1911 ... graduate of New York University ... learned to fly at Randolph Field 1933 ... did early flight testing on Seversky P-35, Curtiss P 36, Lockheed P 38 and Republic P 43 ... Postwar served as chief of aircraft branch USAF Hq directorate of research and development, 1946-50 ... assistant deputy for development when ARDC was organized in 1951 ... took command of Flight Test Center in January 1952

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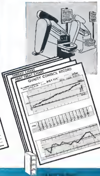

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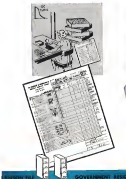

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Drilled Fillister Head Machine (Fine Thd.—Coarse Thd.) AN502—AN503
Machine, Round Head (Coarse Thread—Fine Thread), AN515—AN520
Washer Head, AN525
Machine, Truss Head AN526
Sheet Metal Round Head, AN530

SCREWS—Phillips Recessed

Machine, Flat Head, 82° (Coarse Thd.—Fine Thd.) AN505—AN510
Machine, Round Head (Coarse Thd.—Fine Thd.), AN515—AN520
Machine, Truss Head, AN526
Machine, Flat Head, 100°, AN507
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BOEING B-29 "stork" plane carries a late model Bell X-1 research aircraft aloft for launching on supersonic flight test

or level flight. This consists of a radar photo theodolite, an electronic plotting board, and electronic rate of change of altitude recorder and a photo recorder.

In addition, the National Advisory Committee for Aeronautics maintains a highspeed research facility on the base. A new $3 million NACA installation now is under construction.

Test Phases

Air Force flight testing at Edwards breaks down into three phases. Other phases are conducted elsewhere, either by the contractor or USAF.

- **Brief Phase II** testing is the first Air Force test of a new aircraft. After 20-50 hr. of flight testing by the manufacturer, AFFTC runs a short test to check performance guarantees and to determine potential value of the aircraft to the Air Force.
- **Phase IV** testing begins with the first of a series of production aircraft. It checks performance and stability characteristics in detail and relays this performance data to WADC for use by the Flight Data branch in checking the contractor's figures. Information on control forces and deflections is passed along to aeronautical design groups at WADC. Phase IV testing may require up to 150 hr. flight time.
- **Phase VI** tests use three or more of the first production models of a new aircraft. Commands which will use the airplane, such as Tactical Air Command or Strategic Air Command, as well as the Air Proving Ground, are invited to send pilots and maintenance personnel to take part in Phase VI tests, which simulate operational conditions on night, weather, maximum range, gunnery and other missions. Phase VI testing requires about 150 hr. per aircraft.

The AFFTC project engineer prepares a report at the end of the test in which he sets up maintenance requirements, parts consumption and inspection times. Field commands use this report in drawing up operating requirements.

Throughout these tests, information is relayed to the manufacturer for correction of deficiencies. The aircraft then goes to Air Proving Ground for tactical evaluation.

"At the end of Phase VI, we report that here is a machine or weapons system capable of doing a job," explains Lt. Col. Jackie L. Ridley, chief of the flight test engineering lab. "Air Proving Ground Command at Eglin then works out how this machine or weapons system can be used by a tactical unit. We determine its flying characteristics, they determine its combat capabilities."

▶ **The Sophisticated Approach**—Edwards aims at a mature, sophisticated engineering approach to flight testing, according to Gen. Holtoner. "This is no rowdy testing," he says. "It takes real scientific knowledge to do the job." Occasionally, however, even a scientific pilot cannot resist the opportunity to wring out his aircraft in spectacular fashion.

Maj. Chuck Yeager recalls, for instance, an early flight in the X-1 when he buzzed the tower with the rocket engine dead, then kicked in all four rockets to start up into what was to have been an Immelmann.

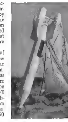
"The next thing I knew I was upside down at 35,000 ft., the nose fell through and I shot up to .86 Mach. It was somewhat of a surprise."

▶ **Production Models**—Most flying at Edwards, however, is not in research aircraft but in forthcoming production models. The Air Force Flight Test Center, and ARDC in general, concerns itself with the quality of aircraft production—while Air Materiel Command worries about quantity of this production. Under new USAF production concepts, testing at Edwards becomes even more important.

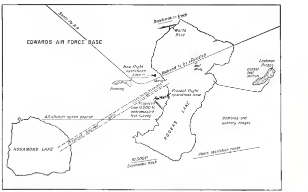
Flight testing leads the center into a small amount of actual research and development work as it devises corrections to overcome aircraft deficiencies. Much of the design development in "flying tails" and "slab tails" came as a result of Edwards flight testing when test pilots discovered that the standard combination of elevator and stabilizer failed to function as transonic speeds were approached. F-94C drag chute development work was done here.

Flight Tests And Development

Heart of AFFTC's flight testing is the Directorate of Flight Tests and De-



COOK missile after free fall test



velopment, headed by Lt Col Walter L. (Mickey) Moore. It consists of four laboratories

- Flight test operations.
- Flight test engineering
- Engineering
- Maintenance

▶ **Flight Test Operations**—Pilots from the fighter, bomber and cargo sections of flight test operations do the actual flight testing of research, prototype and production aircraft, as well as engines and components

Twenty-one test pilots, all graduates of the Experimental Flight Test Pilot School, are assigned to this group under Lt Col Frank K Everest In addition to their duties at Edwards, these pilots work closely with contractors, attending mockup and technical compliance sessions and flying prototypes even before delivery to the Air Force. Their services also are available to other commands

One Edwards test pilot departed recently for France to evaluate two French jet trainers at the request of Air Training Command

▶ **Flying Degrees**—When you needed a test pilot in flying's early days, you looked around for a chap with a devil may-care attitude, a terrific amount of flying ability and no family. Although a few specimens of the "booze, blondes and biplanes" species still roam the desert wastes of the Mojave, the job is different now

Many of AFFTC pilots hold engineering degrees and in some cases serve as both project engineer and project pilot for a test program In addition to testing of new production aircraft and components, the pilots fly research aircraft such as the X 1, X-4 or X 5 in a search for original aerodynamic data They also fly pacer aircraft on airspeed calibration missions

▶ **Saved by the Chaser**—One of their most important jobs is the flying of chase aircraft during experimental flight testing A number of pilots owe their lives to the presence of these chase planes in time of trouble

"They're a must for sure," says Bill Bridgeman When Bridgeman was taking the Douglas D 558-II to record speeds and heights, Maj Yeager and Col Everest were assigned as chase pilots

"There's no doubt that Chuck and Pete saved me from busting up my tail a couple of times," Bridgeman recalls "I inadvertently spun the Skyrocket once I got to thinking I knew what I was doing in lowspeed stability and got into a spin Chuck kept calling my altitude until I worked out of it"

When Bridgeman edges the high-speed X-3 down toward the lakebed for landing, Yeager, flying his wing in an F-86, helps him overcome a difficult problem of visibility by calling off the altitude—"eight feet to go, seven feet, six feet . . . . "—as they descend.

"He's a nice quieting influence," the Douglas test pilot comments "It's nice to have him along I miss him when he's not there"

Fellow pilots say Yeager saved the life of an NACA pilot flying the X-4 when he noticed from his chase plane that the pilot was suffering from anoxia He coaxed him down to altitudes where oxygen was more plentiful

▶ **Seeing Eyes**—Everest himself tells of three blind landings in the X 1, with a chase pilot talking him down to the lake each time. The emergencies were caused by heavy frosting of the cockpit canopy at extremely high altitudes In spite of the desert heat, the occurrence is not uncommon in testing of research aircraft which make rapid descents from altitude to deadstick landings on the lakebed

During first flights of the YB-52, it was a chase pilot who discovered oil leaks and engine backfires before they became noticeable to the pilot. When a 10,000-lb. dummy bomb tore loose from a B-45 in flight, ripping off bomb bay doors, damaging the bomb bay and smashing the stabilizer, it was the chase pilot who reported to the pilot on damage invisible to crew members in the B 45

"The chase pilot just about puts his head up my tailpipe to check for fire or other dangers for me," is the appreciative comment of one civilian test pilot.

▶ **Flight Test Engineering**—For every

Flight Test Center Insignia

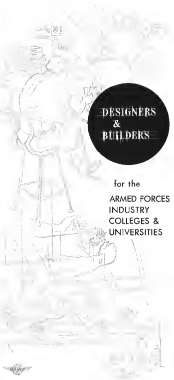
hour of flight testing at Edwards, the flight test engineering lab puts in roughly 30 hr on the ground on the same project, determining the air maneuvers which the pilot will follow

Most of the aeronautical engineers at AFFTC are assigned to this section under Lt Col Ridley Majority are civilians but here again are found Air Force engineer-pilots who have combined their technical knowledge with an aeronautical rating

When WADC sends out a program, it is the flight test engineers who translate the program of required data into a series of flight test maneuvers They decide how the information must be obtained, what instrumentation is required to obtain it They make up the test cards which the pilots follow aloft Together with the pilot, they write the report, using IBM machines to reduce much of the data

Flight test engineering lab is made up of six groups

- **Flight research branch,** which decides upon flight techniques for conventional aircraft and determines criteria for testing new types of aircraft and components, such as helicopters or turboprop engines Long before a prototype appears at Edwards the flight research branch is drawing up a test program for it
- **Instrumentation branch,** which develops, installs and maintains the elaborate instrumentation required for flight testing Test instruments from Edwards often are installed in the first production aircraft as it moves down the contractor's assembly line, thus saving both time and money
- **Performance test branch,** which prepares Phase II and Phase IV flight plans—tests related to performance and flight characteristics
- **Flight development test branch,** which prepares Phase VI flight plans—tests related to functional development
- **Human factors branch,** which tests



Col Marion Akers, Chief of Staff

personal equipment and studies aeromedical problems during Phase II and Phase IV flight tests, a program aimed at evaluating the place of the pilot in each air weapons system.

• **Data reduction branch,** which transcribes and computes data for the entire flight test engineering laboratory.

▶ **Engineering Lab**—Testing not done in the air is the concern of another of the labs of the flight test directorate, the engineering lab. Major group in the engineering lab is the powerplant branch, which runs static tests of both rocket and jet engines.

Charged with the development and testing of these engines, the power plant branch also supplies engineering assistance for experimental flight testing. It recommends overhaul and inspection periods for the engines of USAF aircraft.

Described by Col. Moore as "almost a maintenance facility itself," this versatile system designs much of its own test equipment and is authorized to do major overhaul on all types of aircraft engines.

Other engineering lab branches include the photo branch, which tests new cameras, lenses and film, and the armament branch, which runs tests on bomb systems, gunsights and armament of new aircraft.

Currently the armament branch is helping evaluate the Hughes Aircraft E-4, E-5 and E-6 fire control systems in a study known as Project 456. The engineering lab also is responsible for the track branch, which controls the high-speed and deceleration tracks, and the rocket branch, which operates the rocket engine test facility.

▶ **Maintenance Lab**—Last of the directorate's four labs is the maintenance lab, which faces the problem of maintaining what is probably the most

Lt Col Walter Moore
Director of Flight Test & Development

varied assortment of aircraft, power plants and avionics equipment on any Air Force base—some 33 different types of aircraft, ranging from one-of-a-kind research craft down through small Army liaison planes.

F-84F Project

The F-84F testing serves as a good example of an actual flight test program, although more urgent than usual due to the necessity of testing both a new aircraft and a new engine under the strain of foreign commitments which give the project a 1-A priority. F-84F is slated for MDAP in Europe and Far East Air Forces in Tokyo.

▶ **Thunderstreak History**—Security covers much of the exact data revealed by the program but testing of the new Republic Thunderstreak fighter can be outlined in general terms.

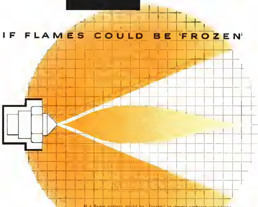
When flight test engineering learned the date of delivery of F-84F production models to the Air Force for Phase VI testing, a comprehensive test program already had been outlined, listing the specific number of hours intended for gunnery, formation flying, night flying, inflight refueling and other missions. Capt. Orville Scroggins was project engineer and Maj. Ray Popson, project pilot.

Flight test operations and other facilities were alerted and scheduled the project into their workload. The necessity of close scheduling becomes clear when one realizes that the 23 project engineers in the flight test engineering lab have a backlog of more than 80 projects.

Ordinarily six aircraft are sufficient for the Phase VI tests, but, as several major problems developed, it was apparent additional aircraft would be necessary, says Col. Ridley

5

IF FLAMES COULD BE 'FROZEN'



If a flame pattern could be "frozen" at simple ambient conditions, and then methodically reproduced to perform under all flight conditions—life in the combustion engineering business would be a lot simpler. The fact is, of course, that theory gives out long before the perfect picture has been drawn.

And so . . . to achieve higher-than-ever combustion efficiency . . . to locate electrodes in just the right place for positive ignition . . . to develop new tricks (like sweat cooling) for elimination of hot spots . . . to produce controlled turbulence . . . to cut down resonance . . . in short, to get flame to conform to plan is a basic objective we reach through use of the large fund of flame facts we've built over the years. If you face any of these combustion problems, your Janitrol representative can quickly show how our facilities may fit into your program.

Speaking of freezing, an article on a mysterious case of ice formation on fuel nozzles in combustion heaters—and how our engineers tracked down the cause — appears in the Janitrol Heating Digest, Vol III, No 3. Another Janitrol publication, "Heat in Harness," gives a broad view of how several Surface Combustion Corp Divisions work together in the advancement of combustion engineering.
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Lt. Col. Frank K (Pete) Everest
Director of Flight Test

The flight test center requested an additional six.

The project engineer estimated the number of hours needed on each aircraft but this figure was kept flexible as "bugs" developed. Usual average is about 150 hr per aircraft

▶ **Speed-up**—When trouble developed, a hurried decision was made to place the F-84F project on a "7-day week, around-the-clock" basis Outside personnel were called in to assist with flight and maintenance duties

Normally, during Phase VI testing, such organizations as TAC, SAC, ATRC and ADC are invited to send pilots and maintenance personnel to participate, thus building a nucleus of experienced personnel in each command familiar with the new aircraft

▶ **Stretching the Shoestring**—"In this case, however," says Col Ridley, "we had to ask for definite numbers We're operating on a shoestring, anyway, and when we go over the usual number of aircraft for a program, it's impossible to operate without outside help"

Any outside pilots who were flying in the test program the weekend four F-84Fs made emergency landings on the lakebed will carry back to their home commands a glowing report of the value of Rogers Dry Lake to the flight test center.

Unable to stockpile engines because Wright was just getting into production with the J65, the flight test center called in Slick and Flying Tigers to supplement its own cargo aircraft in flying spare engines from the East

Although security cloaks exact details, the shattered parts of an exploded engine crated for shipment back to Wright told their own tale of trouble Inspections were set at 15 hr., then mounted to 25 hr. as fixes began

▶ **F-84F Fixes**—Meanwhile, test pilots

■ EDWARDS

were uncovering problems in the aircraft itself. These, listed by Col. Ridley, can be revealed:

- **Cracks in the duct** proved a need for reinforcing. This was relayed to Republic for a fix.
- **Landing gear redesign** was required. Kits now are out for this.
- **Heating and cooling system** changes were needed.
- **Landing gear handle** required redesigning because the detent was not large enough and pilots were pushing the handle past the down position to "emergency down."

The system of Unsatisfactory Reports (URs) was bypassed on fixes because of the time element. Daily, weekly and monthly progress reports were submitted and followed later by URs. Progress reports were supplemented by almost daily telephone conversations. Thus, Phase VI testing moved ahead on a new USAF fighter.

Edwards' Tenants

The high-pitched whine of the Sapphires dominated the Edwards flight line during the F-84F test program. But the sounds of a wide assortment of other aircraft were reminders of the many "tenants" with whom the Air Force shares its desert test base.

▶ **NACA's Stable**—One of these is the National Advisory Committee for Aeronautics, which houses its strange stable of white research craft at Edwards and is building a multi-million-dollar facility linked to Edwards' master plan.

Building aerodynamic knowledge with their highspeed research aircraft as tools is the task of NACA's 220 employes, under the direction of Walter C. Williams. Projects include the following:

- **XF-92A**, which is producing a background of delta wing knowledge for such aircraft as the Convair F-102.
- **D-558-II**, an improved aircraft since Bridgeman returned to report wild highspeed oscillations. The Skyrocket is flying a full schedule to study these oscillations further. Although no modification of the D-558-II was designed specifically to make it go faster, those familiar with the aircraft say it now is capable of breaking its own speed record of 1,238 mph.
- **X-5**, Bell's adjustable-wing aircraft for testing variable sweep, is being used to study problems of extreme sweep in the area where drag diminishes but stability and control problems increase. NACA research is seeking the area where combination of minimum drag with maximum control exists.
- **B-47** research flights are studying aeroIasticity problems.
- **X-1**, currently off flight status, is be-

ing reworked to a low-pressure fuel system

Research programs employing the D-558-I and the tailless X-4 have been completed. Two new research aircraft, the X-2 and X-3, have not yet been delivered to the research center. NACA personnel have been assisting in Douglas flight testing of the X-3, however, and the aircraft will be turned over to NACA in December, according to Douglas sources.

► **Cramped Quarters**—The 18 contractors at Edwards (total personnel 1,309) are jammed into crowded facilities that make their desert working conditions difficult. Several have taken over facilities at North Base, the original Muroc test site some 7 mi. from the main base.

In spite of Air Force and industry efforts to extend the life of World War II temporary buildings and hangars at North Base, it is more reminiscent of a forward fighter strip in Korea than a stateside installation. The 6,500-ft. runway is set counter to prevailing winds and the only taxiway joins it at the center.

► **Contractors' Operations**—A look at North American, Northrop and Douglas operations gives some idea of the place of the contractor at Edwards.

• **North American Aviation** uses North Base as the center of its flight test operations but also runs tests from the main base and from its home plant at Los Angeles International Airport. Northrop, on the other hand, does all its experimental flight testing at Edwards.

According to J. F. O'Brien, engineer in charge, NAA's 250 technicians currently are engaged in such projects at Edwards as supersonic testing of the F-100 prototype, evaluation of the F-86D fire control system, external stores testing of the F-86F fighter-bomber configuration and contract testing of the new F-86H. Other NAA projects at Edwards are classified.

• **Northrop's** 188 employes, operating out of North Base under the direction of R. W. Rolfe, are at work on such projects as flight testing the modified F-89D and components of the F-89C.

• **Douglas Aircraft** joined the group of contractors at Edwards six years ago as the result of a Navy project—the D-558-I. When Douglas and the Navy asked permission to use the lake for a testing of the Skystreak, the Air Force assigned the company to a then-empty hangar at North Base.

Since only tankage available for liquid oxygen was on the main base, it became necessary for Douglas to move to a hangar there when testing of the rocket propelled D-558-II began.

"It was a bare hangar, no water, no

toilets, no offices, no anything," says Al Carder, chief of the Douglas unit. The Navy put up the money to build offices. Douglas borrowed four airmen from the Air Force and stripped a compressed air system from the Mojave Navy base for installation in the hangar. Edwards supplied utilities. Operations then began on projects which have been largely Navy.

Only Douglas USAF project now underway is the X-3 testing. But the Air Force receives a weekly report on Navy work in progress at Edwards. Carder sums up the position of all contractors on this ARDC base when he says: "We are tenants but it's a peculiar situation because the landlord is the customer."

Master Plan

The Edwards master plan already is well under way. Its aim: to convert the present wartime hodge-podge of training and test facilities into a modern flight test center for the nation's military services.

As early as 1924 such firms as Northrop and Lockheed were using the area (then Muroc Dry Lake) for testing. Sir Hubert Wilkins flight tested his Lockheed Vega at Muroc in 1924 prior to his polar flight. Jack Northrop tested his first flying wing in the area before 1930. Present military use of the dry lake began in 1943 when North Base was constructed as a secret test site for the first U. S. jet fighter—Bell's P-59A. After World War II, the test center expanded to its present location, a wartime training base.

While the master plan was drawn up in 1947, it was not until 1951 that the base was designated a full-fledged flight test center. Prior to that time, AMC detachments traveled to Muroc on specific flight test projects and then returned to Dayton.

▶ **Modernization Needed**—Need for modernization of the base is obvious. Hangars are jammed with aircraft, forcing mechanics to do much of their major maintenance work under a hot desert sun which pushed temperatures as high as 112, when tools become too hot to pick up and aircraft surfaces blister the hand if touched.

Ancient wooden buildings have been painted many times to ward off the desert climate.

The runway, designed for 35,000-lb. loads, frequently is called upon to take loads almost 10 times that with modern bombers.

It costs $1.5 million a month to operate the base in its present condition. Gen. Holtoner and his staff believe maintenance savings alone would amor-

tize the cost of a completely new base over a few years.

Some $40 million has been appropriated for new construction under the six-phase master plan. Less than $3 million of this remains unspent, according to **Lt. Col. Malcolm P. Elvin**, chief of the base development division.

▶ **New Runway**—Construction has started on a new 15,000 ft. runway which will be 200 ft. wide and capable of supporting 500,000 lb. loads. This will be extended by a 22-mi. freeway, bulldozed through the desert to Rosamond Dry Lake, thus giving a clear area for straight ahead emergency landings of 22 mi.

For additional safety, there will be a one mile clearance on each side of the broad runway. Col. Elvin questions whether even this is sufficient for experimental flight testing.

At a takeoff speed of 180 mph., Elvin points out, a pilot who swerves off the runway has only 20 sec. to get his aircraft under control before he hits the buildings.

▶ **Other Construction**—Work also is underway on new roads, barracks, an instrumentation and calibration shop, the technical engineering and administration building, engine repair building and a new hospital. Defense Department has released funds for a radar and telemetering building.

A remote storage area for unconventional fuels will handle the fuels and oxidizers necessary for rocket engines, such as nitric acid, hydrogen peroxide, liquid oxygen, alcohol and aniline. Underground pipelines will deliver these to the flight line and the 20-mi.-distant rocket engine test facility.

Other facilities planned for the new flight test center include a hangar and shop combination equipped to do major maintenance and modification, three large hangars (with room for a fourth) and a data reduction building. NACA plans two hangars in addition to shop and office space.

Target date for completion of this national flight test center? Two years ago, according to Col. Elvin.

The master plan, designed to permit rapid expansion of base facilities in the future, is planned for a personnel strength of over 28,000 on a 300,000-acre base.

Some 6,000 personnel now are assigned to Edwards, and total population, including dependents, approximates 10,000. There are 1,150 family-type houses on the base in addition to the 500 other buildings, which include two large hangars and a number of smaller ones. Lake landing area is supplemented by a concrete runway and ramp.

TEST PILOTS study stability and control problems in Edwards classroom.

Edwards' Exacting School . . .

Where USAF Trains Test Pilots

It takes only a glance at the recording instruments packed into the long needle nose of the X-3 or a look at the many technicians swarming over the glistening white craft as it squats in the hot sun on the Edwards AFB ramp to know that the job of a test pilot is not as simple as it once was.

Test flying today's complex aircraft demands pilots not only of unusual flying ability but with a strong engineering background.

That is the task of the Air Force's Experimental Flight Test Pilot School here: to turn out test pilots who are a match for the aircraft they fly, who are adept at engineering evaluation as well as flight test techniques.

It is one of five such schools in the world. The others are the U. S. Navy school at Patuxent, Md., and test pilot schools in England, France and Russia. The school here has the sole responsibility of supplying the U. S. Air Force with qualified test pilots.

▶ **Student Bridgeman**—There is one familiar name on a locker in the pilot's room of the school: Bridgeman. Bill Bridgeman, top Douglas test pilot who flew the D-558-II Skyrocket higher and faster than man has ever flown before, who currently is testing the supersonic X-3, is a student in the school.

Bridgeman, with no formal education in flight testing, is brushing up on his engineering background. He finds the school program valuable.

"It's one helluva bit of work," he admits. "It's pretty tough for us old men to go back to calculus."

Calculus is but one tough course in a rugged six-month program of flying and ground school, divided into performance and stability phases. Going through the school is no part-time task. Bridgeman, who has finished one phase, is being held over a class because of the time he must devote to the X-3 project.

▶ **AF in Majority**—As a civilian, the Douglas test pilot is an exception in the school. While one contractor pilot and at least one RCAF pilot are accepted in each class, the majority of the students is composed of well-qualified Air Force pilots.

Entrance requirements for the school, which was moved to Edwards from Wright-Patterson AFB in 1951, are stiff. At least one combat tour, either in World War II or Korea, is a must for AF candidates. They must have at least 1,500 hours of diversified flying time, be between 23 and 33 years of age, and have a knowledge of college algebra, trigonometry, solid geometry, differential calculus, aerodynamics, and allied subjects.

School officials give preference to men with engineering degrees. If the candidate is a reserve pilot, he must agree to remain on active duty for three years after completion of the course. Qualifications are evaluated on a point system and a high ranking board selects

the 15 pilots permitted to enter the school each three months

▶ **Who May Apply**—Prior to Jan 1, only those pilots assigned to ARDC's Air Force Flight Test Center at Edwards were eligible for the test pilot school. Now, qualified pilots in any USAF command can apply. Top graduates are assigned to flight testing at Edwards. The remainder are sent to other ARDC bases.

Graduates, awarded the Air Force specialty rating of Experimental Flight Test Officer (AFSC 8741), are qualified to perform both Phase II and Phase IV flight testing for the Air Force.

Some idea of the academic level of the courses can be gained from the fact that four of the five [illegible] instructors presently assigned to the school (authorized strength: seven) hold master's degrees. This includes the commandant, Lt. Col. John R. Amann. A calculating machine on the desk of each student offers another measure of the difficulty of the courses.

▶ **Six Months = Two Years**—Since textbooks on how to be a test pilot are rare, the instructors in some instances have written their own. One of these is by Maj. James H. Polve, chief of the performance section.

"In six months a student here gets the equivalent of what a college engineering student gets in his last two years," Maj. Polve says.

Fundamentals of flight test evaluation are taught in the first three month phase of the school, the performance course. Here the student pilot gets an intensive refresher in algebra, trigonometry, calculus, physics and applied mechanics. He sweats through ground courses in theoretical subsonic and supersonic aerodynamics. He receives instruction in flight techniques, theory of aircraft performance, flight test data reduction methods, and the writing of project reports.

▶ **Practical Work**—He flies timed speed runs, speed-power tests, sawtooth climbs, and other flight tests. During the performance phase, he chalks up some 30 hr. flying time.

In the stability and control course, the students learn the minimum-acceptable flying qualities of aircraft consistent with safety and acceptable control. More ground school is on the agenda plus 35-40 hr. flight time.

The school's "air force" of gaudy red and yellow aircraft includes six B-25s (for the stability course) and five T-28s, two T-33s, two F-80s and two F-84Es (for the performance course). The school, with a total personnel strength of 10 officers, 26 airmen and 42 civilians, does its own maintenance and instrumentation.

▶ **Instrumentation**—The aircraft in the school's hangar are carefully instrumented with such devices as yaw met-

TEST PILOT reports on F-86D flight.

ers, sideslip indicators and force instruments. Ballast water tanks in the B-25s permit shifting of aircraft CG from as much as 18% forward to 33% rear. Movie cameras monitor duplicate instrument panels to supplement data recorded by the pilot. Projects are similar to those the student will encounter when he graduates into regular test flying.

Flying begins at dawn to take advantage of morning hours when the desert air is calm, the afternoon is devoted to four hours of ground school. A two hour examination each week helps the instructors keep track of students' progress.

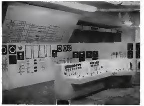
▶ **Quality, Not Quantity**—Like most Air Force schools, there is a procedure for "washing out" those who are deficient in academic or flying ability.

"Although 15 students every three months just barely take care of normal test pilot attrition due to transfers and other reasons, we are interested in quality, not quantity," Maj Polve asserts.

An Air Force document defines the purpose of the test pilot school this way:

"Only a sound understanding of basic principles and an insight into the advanced problems of aircraft design and operation will permit the test pilot of today to gather and interpret precise data, and to analyze the new experiences he will undergo and express these experiences with clarity to test engineering personnel. The skilled test pilot, only, can correctly evaluate aircraft for use in highspeed warfare."

"If you are looking for a more dramatic way to express what we do here," adds Maj Polve, "you might put it like this. The world depends on the U.S. Air Force and the Air Force depends on its planes. The quality of those planes depends on the test pilots who evaluate them. We supply the pilots."



ETF CONTROL is handled by two operators from this console

GIANT CRANE hangs over motor house for propulsion tunnel.

HEADER TRENCH houses a myriad of pipes and valves for GDF.

REFRIGERATORS cool the air heated by compressors of ETF.

AEDC Will Speed Air Development

These giant facilities that no contractor could afford to build himself will ease the 'growing pains' of new designs.

By David A. Anderton

Tullahoma, Tenn.—The combat airplanes and engines of 1960, now taking shape in nebulous outline on drawing boards, will be eased through youthful growing pains at the Arnold Engineering Development Center.

In three test installations now a-building, future airframes and powerplants will undergo their first full-scale simulation of flight at extreme altitudes and speeds.

From precise measurements of pressure and temperature, from the recorded readings of gages and manometers, designers will learn what they want and need to know without resorting to lengthy, expensive—and possibly unsatisfactory—flight tests of the equipment.

▶ **Tremendous Capabilities**—The three major units of AEDC—engine test, gas dynamics and propulsion windtunnel—will encompass a staggering range of capabilities in speed and altitude which are built around the theme of contractor service.

"The philosophy of AEDC is that it should be a development center for industry. It's something that no company could afford to build by itself," said Col. F. H. Richardson, AEDC Chief of Staff.

"The contractor who comes here to test can either operate the test unit or monitor the tests. He'll have maximum freedom to do as he pleases. His proprietary rights will be protected. We'll schedule the tests and provide support. And under present plans, all this won't cost him anything," Colonel Richardson added.

"We're just beginning to undertake our first development test project," said Richardson. "And we're blowing some air through a small supersonic tunnel for calibration purposes. We should be running some of the engine test cells this summer, and begin program tests in the fall."

▶ **Testing Trio**—Of the three gigantic test facilities at AEDC, the Engine Test Facility (ETF) is nearest completion. Col. Richardson estimated that its design was 98% completed, and that construction was 95% along.

Construction of the Gas Dynamic Facility (GDF) is about 40% finished, and of the Propulsion Windtunnel (PWT), only about 25%.

There is a Ramjet Addition (RJA) to the ETF—currently considered as an extension of the engine facility—that will exceed it in capacity and stand in its own right as a major facility. Construction on this addition has only begun, and most of the work is still in design.

▶ **Test Cell Details**—The detailed capability of each test cell is classified information. Size and performance of each unit have been detailed in the accompanying box, as far as permissible. But it should be remembered that test section size and model size, although related, are not one and the same. The giant PWT, with its 16 ft. test section, will be able to test models of airframes or full-size engines up to a diameter of only about 4 ft.

Generally each facility has been designed to meet the test requirements of the largest foreseeable unit to be tested. Again, using the PWT as an example, its test section has four times the area thought adequate several years ago. The Ramjet Addition will be able to blast air through a single test cell in amounts far above current and near future ramjet air flows.

Engine Test Facility

Nearest to completion at AEDC, the Engine Test Facility had a headstart in Germany during the war. It was planned as a central test unit by the German government, and located at the Munich plant of the Bayerische Motoren Werke (BMW). Completed in 1943, the test facility had an air capacity of 53 lb. per second, a single test chamber and a simulated altitude range reaching 45,000 ft.

Testing soon brought out the limitations of the BMW plant, and so a larger version was planned. Most of the machinery was completed for the newer plant, but never installed.

▶ **Postwar Import**—At the end of the war, German engineers operated the plant for British and American tests, including the first high-altitude test runs of British jet engines. Then dismantling began and the original plant together with the machinery for the new test facility, was shipped to this country as reparations.

Lt. Col. F. W. Williams, AF project officer for ETF, told Aviation Week that the German plant was worth between $3 million and $10 million against the cost of AEDC, depending on whether the value was figured in the dollar equivalent of German marks, or in the replacement value of the equipment in the United States.

"All the compressors and all but one motor in ETF are German," Williams said. "We surveyed all the switchgear and used the good parts on the air side, but had to buy switchgear for the exhaust side. The test cells are similar to the original BMW cells, but are not the same units."

▶ **Higher Rating**—Redesign of the original German layout, plus more equipment built in the United States, have raised the rating of ETF from 53 lb. per sec. to about 300 lb. per sec. Altitude capability has been almost doubled from the original 45,000 ft. German limit.

Describing the flow diagram will show the general layout of the plant. Air source is a battery of four four-stage, 5,000-hp. centrifugal compressors which feeds through a heat exchanger to a cooler drier.

Three stages of cooling—the first using lake water, the second, chilled water, and the third, ethylene glycol—are required to drop the temperature to −11F and remove the moisture from the air.

At this stage the air can be either cooled further by an expansion turbine, or heated by rerouting through the heat exchanger. Mixing valves control the temperature, and the air then enters the test cell in operation.

▶ **Hungry RJA**—For increased temperature, the air can be routed through the big heaters in the RJA, for increased flow, the air can be combined with the output of two 15,000-hp. compressors in the RJA.

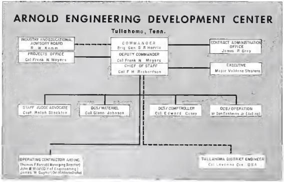
The test cells of the RJA will be able to gulp the air capacity of the entire plant—six compressors—boosted through a second-stage 38,500-hp. compressor and heated. This flow will be far above that of the ETF.

The downstream side of the test cells is connected to a battery of six exhausters, valved so that they can be used in series, series-parallel or parallel flow.

The RJA exhaust goes through two 30,500-hp. exhausters, then back to the ETF exhausters.

▶ **Central Control**—The entire plant is controlled from a central room and console which can be manned by two, or at the most, three operators. The test

COOLER SECTION in return circuit of the Propulsion Windtunnel has 55 ft. dia.



crew, located in the test-cell control rooms some distance away, ask for the flow conditions they need in the tests. Central control then goes into action, sets all the valves and starts the motors.

With stabilized flow established, central control telephones the test-cell crews and tells them to go ahead with the tests

In the engine control rooms, the test crew mans the instrumentation and control equipment necessary to make the specific run. They cannot see the engine, which is inside the enclosed steel tube of the test cell, so observation is by direct TV connection with the cell.

The TV system—not new, although relatively unproven in test—has been received at AEDC and is under test

These control rooms are relatively quiet, due to soundproofing and vibration isolation through floating construction. Lined with panels of instruments and huge manometers, the atmosphere is one of neatness and efficiency.

▶ **Test Cells**—Engine test cells can be lengthened to take a variety of extra installations such as afterburners or special exhaust cooling devices The engine itself is mounted on a cart, complete with instrumentation connections Quick disconnects on the cart, and a huge one on the entire test cell, minimize the downtime between tests.

The carts, handled on rails throughout the plant, are made up in adjoining areas for assembly and shop work. Removable partitions for these areas will be available for protection of contractors' proprietary rights

Test measurements will be processed in digital form through a computer that will give the test crew final data within 30 seconds after the measurements have been made

Brig. Gen. Samuel Ross Harris, Jr., commander, Arnold Engineering Development Center . . . born Pittsburgh, Pa., 1902 . . . graduated from U S Military Academy 1926 . . . learned to fly at Brooks and Kelly Fields . . . rated a pilot 1927 . . . served with 3rd Attack Group in Texas . . . flying instructor . . . test pilot and engineering officer, Wright Field, for nine years . . . director of technical services AAF headquarters . . . director of air traffic and safety development AAF Hq . . . commanded 499th Bomb group on Saipan . . . commanded Panama Air Depot . . . taught at National War College . . . acting chief of programs for ARDC, Washington . . . director of plans and programs ARDC . . . chief of staff, ARDC Hq., Baltimore, where he served until taking command of AEDC

Gas Dynamics Facility

The big feature of the GDF test equipment will be the combination of high Reynolds members with high Mach numbers, which means closer simulation—if not duplication—of full-scale missile flight

Based on a design found in Germany at the end of the war, the GDF is intended to be most useful in the gas dynamic regime where slip flow and free-molecular flow occur "We want to go from Mach numbers above One just as high as possible," said Lt Col J. A Dodge, the project officer

▶ **One Operating**—There is only a single tunnel of the GDF operating now, while construction goes on all around it This tunnel, known as E-1, is a 12x12-in. supersonic setup with a speed range between Mach 1.2 and 5.0, although the higher reaches have not yet been

obtained This tunnel is an exact copy of the one at the Jet Propulsion Laboratory, California Institute of Technology, Dodge stated Internal strain-gage balances will be used for measurement of data.

Most of the compressor equipment, ducting and ancillary equipment is still to come, so the GDF is running on a makeshift basis Right now, four portable Diesel-driven compressors push their output through a tiny tube into a huge high pressure storage bottle 720 ft long with a 3-ft inside diameter This bottle replaces the many manifolded bottles usually used for high-pressure air storage There is another advantage The size and length of the bottle can make it a super-sized shock tube for studies of shock wave phenomena sometime in the future

By operating the four portable compressors on a 24-hr day, seven day week, Dodge said, the facility will be able to make about 250 test runs per day at an average duration of 20 sec per run

On the discharge side of the tunnel is a vacuum sphere, 72.5 ft diameter with walls 1½ inches thick It can be sucked down to 0.1 psi pressure, to provide the tremendous pressure ratio needed across the tunnel to reach high Mach numbers

▶ **Primary Plant**—Actually the high pressure bottle and suction sphere are an auxiliary system The main compressor battery is 12 units—six axial and six centrifugal—powered by about 100,000 hp. supplied by means of electric motors

These compressors and motors are to be housed in a single building, now being completed The size of the building, like everything else at this center, is impressive "in the flesh," and not on paper. You might compare this building to one of the main assembly buildings used by GE or Westinghouse for the assembly of giant hydro-electric equipment

▶ **Big Trench**—Between it and the steel framework which will eventually become the test building is a great hole in the ground, lined with concrete. This is the pressure header trench, and it will contain a maze of pipes, intertwined and twisting around a myriad of valves

This was done for several reasons

STORAGE BOTTLE for GDF is 720 ft long steel tube replacing many manifolded bottles usually used, could serve for shock tube studies.

TRANSONIC CIRCUIT of the propulsion windtunnel nears completion as huge steel rings are erected and covered with structural plate

First, there was a specified difference in elevation between air supply lines and air exhaust. Then these lines needed condensation traps, which meant digging a pit for each valve. Maintenance was a problem, too, so all things considered, the economical solution was to shovel out a big hole and put everything in there.

Propulsion Windtunnel

Back in the days when supersonic tunnel sizes were measuring around 16 inches, the proposals for AEDC asked for a supersonic tunnel with a test section measuring 16 feet.

The power requirement for the tunnel could just be met by the turbines of the largest Navy carriers. Cooling water would course through tubes at a rate that would supply Washington, D. C., with its normal daily needs.

The electric motors which were planned to power the tunnel were simply to be the world's largest rotating machinery.

In all, a collection of superlatives.

▶ **In the Offing**—Least complete of the three AEDC facilities, the Propulsion Windtunnel is still the most impressive. In mid-July, the main structural steel tube for the cooling section of the transonic circuit was standing completed. It is 55 ft. in diameter, which means that you could move an average home right through it.

The transonic circuit is one of two for the tunnel, both will share a common control and power supply. Currently about 35% complete, the transonic circuit is expected to make its first runs late in 1955.

Component work on the supersonic circuit is going ahead, but there are no funds available to construct the final circuit itself. AEDC is thus reluctant to put any completion or first test date on this portion.

The problems of this big tunnel are being studied in a scale model known as "Pee Wee." This model work has already proven out the second throat for the full-size tunnel.

▶ **Kinds of Tests**—This facility is not a windtunnel in the aerodynamic sense, but rather a propulsion windtunnel. The idea is that full-scale powerplants—turbojets and ramjets, mostly—will be tested as installed in their airframes. The test section will be able to handle a configuration of about 4-ft. diameter and 30 ft. long.

The entire test section will be removable from the tunnel to reduce downtime to a minimum. Test articles can be instrumented, and test sections modified without disrupting the operation of the tunnel.

Each tunnel is to feature an adjustable flexible nozzle, similar to the type developed for use in Tunnel E-1 of the GDF. The tunnels will also be equipped with a scavenging system to remove engine exhaust gases and a makeup system which will replace the lost gases with fresh air.

▶ **Motors, Drives**—The rotating machinery for the two circuits is being built by Westinghouse Electric Corp. There are four electric motors, two are rated at 83,000 hp. each, and two at 25,000 hp. each. Coupled to the tandem motor drive will be five compressors—a single unit for air to the transonic circuit, and four to blast air through the supersonic cycle.

The larger motors have been installed at AEDC, the rest of the machinery is nearing completion at Westinghouse's plant in East Pittsburgh.

Size of the compressors is impressive. The shaft is 18 ft. in diameter, and blades are six feet long by about two feet in chord. Weight is about 1,300 lb. per blade.

Westinghouse built a quarter-scale model of a compressor for vibration tests during the development of the machinery. The firm expects to complete work on the compressors in about a year.

Industry Participation

The center and the Unitary Windtunnel Plan were originally justified as being necessary for development use by industry. So it was a logical step to give industry a chance to advise on the policies, operation and design of the facility.

This was done by the creation of the Industry and Educational Advisory Board (IEAB), set up by directive from Gen. Vandenberg, then chief of Staff, USAF, in September 1950. The words of the regulation do not go much beyond establishing the Board and defining the channels it can use. Organization, meeting times, places and agendas are left completely to the membership.

Actually the Board reports to three staff levels:

- **To the Commanding General, AEDC**, on policy matters of design, construction, operation, requirements and plans of the AEDC.
- **To the Commanding General, ARDC**, on relationship of AEDC to other facilities, on advance research trends relating to test and evaluation facilities, and on progress made and problems in policy encountered during the design, construction and operation of AEDC.
- **To the Chief of Staff, USAF**, at least annually on over-all policies of design, construction and operation of the AEDC.

Executive secretary of the Board is Robert W. Kamm, formerly with the Research and Development Board, and before that with Glenn L. Martin Co. and the NACA.

▶ **Board Membership**—The Chief of

AEDC Facilities

Gas Dynamics Facility (GDF)

TUNNEL	SIZE	MACH NO. RANGE	STATUS
A	40 in. x 40 in.	1.2 to 5.0	
B	40 in. x 40 in.	4.5 upward	
E-1	12 in. x 12 in.	1.2 to 5.5	In calibration test
E-2	12 in. x 12 in.	5.0 upward	Deferred: no funds.
*	55 in. x 55 in.		

Propulsion Windtunnel (PWT)

TUNNEL	SIZE	MACH NO. RANGE	STATUS
Transonic	16 ft. x 16 ft.	0.5 to 1.5	35% complete; first runs late 1955
Supersonic	16 ft. x 16 ft.	1.4 to 3.5	Component construction; no funds for completion

Engine Test Facility (ETF)

CELL	SIZE	FOR TESTING	STATUS
T-1	16.5 ft.	Turbojets	Entire facility is 58% designed, 35% completed
T-2	12.5 ft.	Turbojets, turboprops	
T-4	12.5 ft.	Ramjets	
T-5		Components	

Ramjet Addition (RJA)

CELL	SIZE	STATUS
1*	16 ft. dia. x 90 ft.	In design
2*	20 ft. dia. x 60 ft.	Prelim. design
3*	20 ft. dia.	Proposal only

* Not AEDC designations; for identification only.

■ **ARNOLD**

Staff appoints the eight members of the Board. Six are chosen from industry, representing the airframes, powerplant and accessories field, their nominations are made by the Aircraft Industries Assn. Two members represent educational institutions and are nominated by the chairman of the Scientific Advisory Board. Normally named for one year, members can serve for succeeding terms if necessary.

Current chairman is Prof. John R. Markham, MIT, his fellow educators are Dr. C. E. Brehm, president of the University of Tennessee, and a supernumerary member, Dr. Harold Flinsch, dean of engineering at Mississippi State College.

Industry memberships are held by A. T. Colwell, Thompson Products, Inc., Paul J. Frizzell, Fairchild Engine and Airplane Corp., Wright A. Parkins, Pratt & Whitney Aircraft Div., Kendall Perkins, McDonnell Aircraft Co., Maj. Gen. E. M. Powers (USAF Ret.), Curtiss-Wright Corp., Edward C. Wells, Boeing Airplane Co.

There are two supernumerary industry members: Neil Burgess, General Electric Co., and L. A. Hyland, Bendix Aviation Corp.

▶**Internal Workings**—The complete freedom given to the Board is emphasized by its recommendations, everything from broad policy to detailed design considerations have been forwarded by the Board. As of last November, the list totaled 21 recommendations.

Although most of the Board's proposals have been received favorably, a very important one—the question of charging fees for use of the facilities—finds them at loggerheads with ARDC. The Board believes strongly that fees should be charged. Gen. Partridge, formerly commanding ARDC, decided that no fees should be charged during initial operation, and that is the way the matter stands today.

In some cases, the Board has named "ad hoc" working groups to attack the details of specific problems. These groups are chairmanned by a member of the Board, and after exploring a problem, they advise the Board on their thinking. Members of the Board may also call in experts.

Because of the affiliation of the industry members, the Board gets the official AIA viewpoint on the facilities but does not always necessarily subscribe to that view.

Establishment of a Deputy for Operations was one of the specific recommendations of IEAB. This office headed by Donald R. Eastman, Jr., is the connecting link between AEDC and Sverdrup and Parcel Operating Di-

vision (SPOD), which manages, operates and maintains the facility.

▶ **Two Types**—Eastman said there are going to be two general types of contractor tests conducted at AEDC.

• **For government contracts,** any request for a test ought to be preceded by a discussion at AEDC between contractor and laboratory people. This would be simply an exploratory talk and would not result in any promises of tests or schedules. The contractor will get these after he passes his test proposal through his project officer to Headquarters, ARDC.

ARDC will assign broad priorities to types of tests, but AEDC will iron out any last minute requests for changes in schedules.

• **For "proprietary" tests**—which Eastman defined as tests without specific development in mind, but which could involve a contractor's ideas for a family of jet fighters, for example—the procedure would be different.

Plans are to sell time for these tests, although the method of costing has not yet been determined. It will probably be worked out on the basis of charges for the direct cost of electricity, exclusive of overhead.

After tests have been run, the contractor will get preliminary data from automatic data reduction machines. Some early chats with prospective contractors have shown that some of them would like to test for a while and then have a chance to review the data before planning the rest of their test program. This can be worked out, says Eastman.

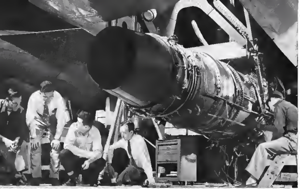
▶ **Living, Eating**—AEDC is without facilities where contractors can stay during their tests, but there are motels nearby.

The contractor personnel will be able to draw on military transportation from motel to AEDC on an as-available basis; they will also be able to use the cafeterias at AEDC.

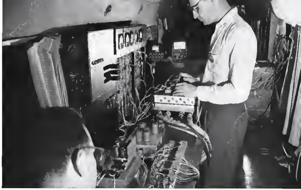
▶ **Air Connections**—At present, AEDC is also without direct air connection; the airstrip is continually being deferred for lack of funds. Air transportation stops at Nashville (82 miles away) and Chattanooga (97 miles away); but the privately owned William Northern field just north of Tullahoma will take non-scheduled aircraft up to 75,000 lb.

There is no control tower, radio or lights at William Northern, so the field is available only under VFR flight plan. "Make sure you buzz the field a couple of times to clear the cattle off," said one of the engineers.

▶ **Industry Conference**—Both Kamm and Eastman spoke highly of the results of a conference held with 15 key people of the Glenn L. Martin Co. recently. "They told us their problems,



G-E JET ENGINEERS study plans of G-E's new engine at Flight Test Center in Schenectady, N. Y. The big powerplant is lowered from B-29 during flight. G-E looks forward—soon—to completely *integrated* armament, engine, autopilot, and electrical system testing.



AUTOMATIC FLIGHT SYSTEMS tests are a daily part of G-E Flight Test Center routine. Advanced model (above) gets final check before take-off. G-E flight control is now installed in Douglas F3D-2 Skynights, Grumman F9F-5P Panthers, and the new swept-wing Grumman F9F-6P Cougar.

"Integrated Testing" Will Improve U. S. Flight Equipment, Save Time and Money

"X" EQUIPMENT gets frequent work-outs in hot planes like this F-86 Sabre, on bailment from Air Force. G-E armament, flight control experts are busy helping the Air Force develop co-ordinated Sunday punches for new U. S. jet planes

PERISCOPE? No—part of a G-E radar-autopilot-armament system. The beam (installed in B-26) measures pitch and yaw signals for determination of system performance. Such devices help G-E engineers get pin-point accuracy in flight-testing new aviation gear

SCHENECTADY, N. Y.—A dramatic new type of equipment testing is taking shape at G.E.'s Flight Test Center. G-E engineers call it "integrated testing." What it adds up to, is this:

Instead of testing G-E aviation gear "piece-meal" (the old method), General Electric is now equipping planes that can evaluate, in the air, new G-E jet engines, new accessory turbines, autopilots, armament, and radar and electrical systems.

Integrated testing—the latest concept in modern aviation engineering—speeds G-E equipment development. Military and commercial customers will receive G-E products in less time . . . at less cost. The products will be better, too, because G-E engineers can know before delivery exactly how each item will affect the over-all performance of a new plane. Here's how the tests will work.

At Schenectady, N. Y., G.E. now maintains an 8-plane "test fleet" which in recent months has included a B-17, B-25, B-26, B-29, two B-45's, F-86's, F-94's, and an A3D. Some of G.E.'s current bailment-aircraft are modified to carry whole systems of test equipment. Jet engines are slung from bomb-bays . . . armament systems set up in the fuselage . . . autopilots and radar systems are mounted in the planes' noses.

Once in the air, G-E engineers "turn on" the test equipment to determine system-performance under flight conditions. Then while sensitive instruments measure responses, automatic recording equipment notes individual *component*-performance—later the results are passed to design engineers, who make whatever system-changes are needed to assure the best, over-all performance.

Procedures like these back up the G-E saying, "Progress is our most important product." The next time you need flight equipment, talk to G.E. first. For G-E equipment is built by men who know the needs of the aviation industry. *Section 210-79, General Electric, Schenectady 5, N. Y.*

GENERAL ELECTRIC

RADOME on tip of B-17 wing at Flight Test Center now carries special apparatus. But pods were originally designed for gunners and wing-tip observers.

we told them ours, and as a result, we're going to be able to get along better when they come here for tests," said Kamm

Kamm and Eastman felt that this was a desirable way of acquainting both industry and AEDC people with mutual problems, and said that they would be willing anytime to meet with similar industry groups at AEDC

"We can show them what we've got to test with, and the kind of data we can give them," said Eastman "They can get acquainted around here, too, and that's important Then they'll be able to walk in here and test with a minimum of small troubles."

▶ **Contractor's Choice**—"As far as we're concerned, the contractor can come down here and conduct his test program any way he wants to," said Eastman "All we ask is a chance to look at his program and decide whether or not it is in the right order

"Obviously, we don't want to crank one tunnel up for an hour, move to another for a few minutes, and then go back to the first one again "

"The only time we'll tell him he can't make a certain test," put in Kamm, "is if we feel that the test won't be safe for the facility "

Operating Division

It's difficult to talk about AEDC without mentioning the Sverdrup and Parcel Operating Division.

SPOD had been operating on an interim basis with four-month contracts, but this arrangement terminated, as expected, at the end of July Gen T F Farrell, SPOD managing director, told Aviation Week in mid-July that a new long term contract was then being negotiated and that the terms of the contract had been agreed upon by both parties The new agreement names Aro, Inc., as the contractor for operation, effective Aug 1.

Originally, operation of the facility was by the firm of Aro, Inc , a wholly owned subsidiary of Sverdrup and Parcel A recent political-financial crisis resulted in the creation of SPOD

SPOD had a separate contract, and mission and financing, and reported separately to the Air Force Apparently things have straightened out now to the extent that the name—if not the structure—of the original operator can be worked into the contract again.

▶ **Major Effort**—Maintenance and operation of the physical plant accounts for the jobs of the majority of SPOD employes They handle all the services of the 41,300-acre reservation—three times the size of nearby Nashville—including its six square miles of reservoir

■ ARNOLD

Peak pumping capacity for the water system is a staggering 250,000 gpm, a rate equivalent to that of Washington, D. C More power is distributed throughout the facility than Nashville uses

The area is threaded with roads, and requires fire and security patrols, communications and motor and rail transportation systems All of these tasks are done by SPOD

The organization chart of SPOD shows two broad functions engineering and administration. The engineers support the tests or perform them, by the loose distinction between groups, everybody else is an administrator Total employment of as of July 10 was 1,318, in a couple of years this figure should be about 2,000

▶ **Engineering Plans**—Director of engineering for SPOD is J M Wild "We're buying time with this facility," he said "We should be able to get as much as 100 test hours on an engine-airframe combination in a month, and it might take years to get that same amount of time in flight tests I know one experimental job that put on only 27 hours of flight time in one year"

One of Wild's projects is to dispel any wrong feelings engineers may have about the type of work to be done at AEDC "We don't want engineers to think that the job is turning valves and reading dials," he said

"There's much more to the work than that We'll have some research projects, for example, associated with the mission

"We want to encourage ideas from young engineers This is a young facility with no pre-conceived ideas"

▶ **University Plan**—Wild outlined to AVIATION WEEK a plan for advanced education which is being worked out by the Air Force, AEDC and the universities in the area

The Air Force began the study of university affiliation with AEDC, and directed its main effort at a graduate degree program SPOD engineers would benefit by being permitted to go on and get higher degrees, AEDC would benefit from the advanced education acquired by its staff The universities would gain financially and scholastically from close contact with the programs and development at the Center

Another phase of the overall plan would establish a cooperative training program, where scientists could do research under the guidance of a university staff and using the incomparable facilities of the Center

▶ **Courses Start**—The University of Tennessee's Extension Division now is offering a large variety of courses to the staff of AEDC Classrooms have been set up in Tullahoma as a service, and

■ ARNOLD

almost 100 engineers in SPOD are taking these courses.

Currently the only portion of these plans in operation is the extension service of the University of Tennessee, but steps are being taken to get the other phases rolling as soon as possible. SPOD management realizes the value of available advanced-education facilities as a drawing card for engineering talent.

How It Began

AEDC had its genesis back in 1944, when some engineers and military people at Wright Field realized that airframe and engine development was about to run out of facilities. In November of that year, Gen. H. H. Arnold—in whose memory the Center was named—asked Dr. Theodore von Karman to study all the possibilities and desirabilities for the future development of the Air Force.

▶ **Super Wright Field**—The end product of the man-hours put in by von Karman and his advisory group was a proposal for a new Wright Field, a super development center for rocket tests, avionic work, parachute development, armament tests, and anything else that the Air Force might possibly need. In this package, of course, were huge wind tunnels and engine test cells, as well as some smaller investigatory tunnels.

The astronomical requirements for electrical power and water supply meant that such a new Center had to be built somewhere other than at Wright Field.

▶ **Deferred**—These ambitious plans were referred by the Bureau of the Budget in 1946 to the Joint Research and Development Board which started a lengthy review of the entire matter.

Because of this delay, and because the legislation for the super Center was tied up so long, the Air Force began to pull out bits and pieces.

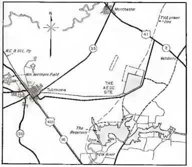
Eventually these pieces were to become—under other names and after considerable discussion—centers of the ARDC.

It was also in 1946 that an executive committee meeting of NACA named a panel headed by Arthur Raymond, of Douglas Aircraft Co., to study the national requirements for transonic and supersonic windtunnels.

The final report of this panel became the initial recommendations for the Unitary Windtunnel Plan. AEDC, because of the windtunnels planned at the Center, became closely involved with the plan and correlated its work with NACA. The gigantic propulsion windtunnel of AEDC became a part of the Unitary Plan.

▶ **Completion Date?**—There is no official date for completion of the Center. A consensus of some of the AEDC and SPOD personnel seems to point to 1957 as an estimate of completion of the currently planned portions.

But in the engineering and development business, there is always tomorrow, and as one engineer put it, "When that designer gets back to his drawing board, we've got to be there to look over his shoulder and figure out what he's going to want to test next."



Missile Center Expands For Long-Range Flights

Cocoa, Fla.—The first pilotless bombers to use the full current capability of the Air Force Missile Test Center are scheduled to roar down the Bahama island chain before winter.

The scarlet missiles, white-marked for better tracking, will speed over the heavily instrumented down-range stations for about 800 miles. Grand Turk Island will be the end of the line for some, but will serve only as a pylon for others that will turn and fly back up-range to a skid landing near their launching point at Cape Canaveral.

For practitioners in the guided-missile art, an 800-mile flight will be a completely new experience. But for the crews manning the down-range stations, it will be just like the simulated runs they have been tracking for many months.

That kind of test capability—being able to handle a range distance which has quadrupled overnight—emphasizes the policies and advanced techniques that have made AFMTC such a potentially valuable laboratory.

▶ **Range Buildup**—In the three years since the first missile—Bumper 8, a two-stage modified German V-2 and WAC Corporal—lifted off the concrete pad at the Cape, the range has been in a constant state of construction aimed at improving and extending the range.

Today the line of flight stretches from Cape Canaveral to pass between stations in the Dominican Republic and Puerto Rico which will be finished in the near future. En route, there are island way stations—fully instrumented auxiliary Air Force bases (AAFB)—about every 150 nautical miles.

Radio communications and a submarine cable link the islands to each other and to central control at the Cape, tying the entire range into a single precision instrument.

▶ **PAA May Run It**—The operation of the range has been done by Air Force technicians, specially schooled by on-the-job training. But at the time of AVIATION WEEK's visit in mid-July, the Air Force was negotiating with Pan American World Airways, in association with the Radio Corp. of America, for contractor operation of the range, presumably on a basis similar to that by which Aro, Inc., will operate the Arnold Engineering Development Center, Tullahoma, Tenn.

The Air Force decision was made on the basis of two counts: the increasing shortage of available technicians in the Air Force, and economy.

Twelve organizations submitted proposals to run the range, each was permitted to define the extent—as well as requested to estimate the cost—of the work to be done. The joint proposal of PAA and RCA received the Air Force's nod, and negotiations began.

Currently, the extent of the job has not been finally defined.

The Range

Launching sites for the range are concrete pads set into the glistening sand of Cape Canaveral. From these pads, the line of flight stretches southeast over the islands of the Bahama chain.

On five of these islands, as in the Dominican Republic and Puerto Rico, the Air Force is completing the installation of auxiliary bases to monitor the flight of pilotless aircraft down-range.

▶ **The Stations**—The first station is on Grand Bahama Island, about 180 miles down. Another 120 miles down is the base at Eleuthera Island. San Salvador station is 200 mi. further on, and marks roughly the 500 mile point of the range.

The site on Mayaguana Island is about 150 miles more, and the last station in the Bahama group is on Grand Turk Island, about 800 miles from Cape Canaveral.

The Dominican Republic site turns the 1,000-mile mark, and by the time the missile passes over the Puerto Rico base, it will have traveled about 1,150 miles.

This fall will see the completion of the range to Grand Turk, and within a matter of months after that, the down-range stations at locations in the Dominican Republic and Puerto Rico should be completed.

BUMPER 8 lifts off firing pad at AFMTC.

ANTENNAS receive flight intelligence.

▶ **Even Longer**—But the range needn't stop at the 1,000-nautical mile mark. If you take a globe and a piece of string, you can see for yourself the ideal siting of the range, should it require extension.

From Cape Canaveral down the chain, between the Dominican Republic and Puerto Rico, the flight line can be extended to cut across the northeast corner of Brazil. From there, the next landfall is the southern tip of Africa, the string finally intersects the west coast of Australia, half the world away!

Brazil would seem to be a practical terminus for the range for some time to come, an impact area there would be about 3,500 miles from the launch point. If the missile could be turned there and flown back, 7,000 miles is the obvious range distance.

RANGE SAFETY TEAM plots position of ships and aircraft inside flight area of missiles, stands by to destroy missile if it leaves limits.

SUBMERGED blockhouse near firing point uses periscope.

CAPE CONTROL station is largest, is nerve center for firings.

▶ **Way Stations**—The down-range stations are technical outposts, manned by 100 to 150 technicians and operated on military basis. Typically, one of these auxiliary Air Force bases will contain complete radio and wire communications, weather station, range safety center, telemetry receiving station, radar and optical tracking center, living quarters for the personnel and an airstrip.

Many small supplies needed for operation are flown in by Fairchild C-119s, there is also an airlift service operated down-range by Patrick AFB for personnel going on or off duty. Most of the bulk supplies are sent down in the holds of landing craft that are operated by the Military Sea Transport Service.

▶ **Navy Design**—Bases were designed by Navy's Bureau of Yards and Docks and built by contractors using materials from the U.S.

All buildings on the base are hurricane-proofed against a 150-knot wind. Half-an-hour after a hurricane warning, the base is buttoned up. All radar antennas and other gear have been removed and put under cover; the other antennas are guyed to withstand the blasts of the tropical fury.

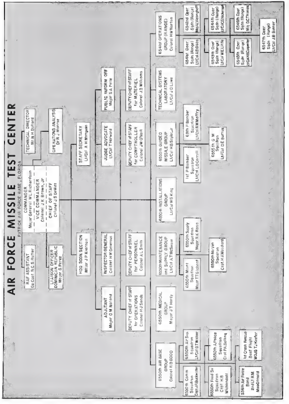
The Men

Civilization has ignored most of the areas around the bases, and native villages are all off limits to the military. In spite of the apparent lack of things to do, the airmen stationed at any AAFB have plenty to occupy their time.

Technically, they keep busy on the continual string of tests which are made down the instrumented chain. If a missile is being fired, they have the usual complement of work to handle. Otherwise a plane carrying guidance or some other kind of equipment for a simulated run will make the trip down-range almost every day.

▶ **Typical Airman**—A man assigned to down-range station has been through basic training, and in addition has had electronics training at Keesler AFB or Chanute AFB. But he will find unfamiliar equipment in his new assignment.

His first training step takes him to


AIR FORCE MISSILE TEST CENTER
PATRICK AIR FORCE BASE, FLORIDA
COMMANDER Major General W L Richardson
VICE COMMANDER Colonel J K Brown, Jr
CHIEF OF STAFF Colonel J S DeWitt
TECHNICAL DIRECTOR Mr N H Bullard
OPERATIONS ANALYSIS Dr R J Monroe
RAF ASSISTANT Gp Capt N G S Rutter
LIAISON OFFICER DOMINICAN REPUBLIC Major G Perez
STAFF SECRETARY Lt/Col A H Manguso
HDQ SQDN SECTION Major J P Kiernan
PUBLIC INFORM OFF Major S A Pelle
JUDGE ADVOCATE Lt/Col T Norward
INSPECTOR GENERAL Colonel H W Generous
ADJUTANT Major O M Noland
DEPUTY CHIEF of STAFF for MATERIEL Colonel J B Williams
DEPUTY CHIEF of STAFF for COMPTROLLER Colonel J W O'Neill
DEPUTY CHIEF of STAFF for PERSONNEL Colonel A L Smith
DEPUTY CHIEF of STAFF for OPERATIONS Colonel H J Sands
6541st OPERATIONS GROUP (RANGE) Colonel H W Norton
TECHNICAL SYSTEMS LABORATORY Lt/Col J O Lowe
6555th GUIDED MISSILE GROUP Lt/Col H B Sayler, Jr
6550th INSTALLATIONS GROUP Lt/Col W G King
6550th MAINTENANCE and SUPPLY GROUP Lt/Col A T McSwain
6550th MEDICAL GROUP Major J T Hardy
6550th AIR BASE GROUP Colonel R B GOOD
6542nd Oper Sqdn (Range) Maj A L Veingsboff
6541st Oper Sqdn (Range) Lt/Col A B Gibbs
6544th Oper Sqdn (Range) Lt/Col O G Nickerson
6543th Oper Sqdn (Range) Lt/Col W E Little
6546th Oper Sqdn (Range) Maj D C Thomas
6545th Oper Sqdn (Range) Lt/Col H B Carpenter
6547th Oper Sqdn (Range) Lt/Col J B Bonner
69th P Bomber Squadron Lt/Col R W Moffry
1st P Bomber Squadron Lt/Col L O Carroll
6555th G M Squadron Lt/Col D E Burrus
6550th Supply Squadron Major R K Rose
6550th Maint Squadron Major T T Gichner
6550th Mo Veh Squadron Capt H A Woodford
6550th Air Sup Squadron Lt/Col G T Walker
6550th Comm Squadron Capt J R Buckwalter
6550th A Police Squadron Capt P A Belling
6550th Food Sv Squadron Capt H B Wichlendahl
1st Crash Rescue Boat Flight WOJG T J Keefer
536th Air Force Band 2nd Lt R M MacDonald

Maj Gen William Lloyd Richardson, commander, Air Force Missile Test Center artillery and ordnance expert born Saginaw, Mich., 1901 graduated U S Military Academy, 1924 appointed second lieutenant Coast Artillery Corps taught tactics at West Point served in operations planning section of War Department general staff organized airdrome defenses of 8th Air Force in England trained anti-aircraft units in U S for combat duty organized and trained 9th Air Defense Command of 9th Air Force in Europe post war chief of guided missiles division, AAF Hq transferred to USAF when it became a separate service became chief of Long Range Proving Ground when it was organized in 1949 and has commanded it ever since.

Jupiter, a training center on the Florida coast which simulates an island base. There he takes a course laid out along similar lines and taught by technicians from RCA.

▶ **Filling the Gaps**—The instructors find out what the man knows to start with; then they give him special training to fill the gaps After that, he has a specialty, his stay at Jupiter is determined by how much extra coaching he needs and terminates when he is considered sufficiently capable of doing his job

An airman intended for guided missile cadres is assigned to the Guided Missile Group and either the 1st or 69th Pilotless Bomb Squadron, which are now being formed to use the Martin B-61 Matador

He may get extra instruction in special phases—guidance, launching, propellants handling When the squadron as a whole is ready, it is reassigned to the Tactical Air Force

▶ **Briefing**—Before they go down-range,

the airman, officer and civilian alike receive a briefing on the geography, history and background of the islands and their peoples

The door to the briefing room has a large photograph of an aged Negro riding a donkey cart down a narrow alley; surcharged across the top of the picture is the motto, "In order to have good neighbors, we must be good neighbors"

Inside the converted Quonset hut which is the briefing room, there are relief maps of the range and of each island On a continuous shelf around the room are samples of the products, currency, stamps and other items characteristic of the islands

▶ **Well-Educated**—It's paradoxical, but man for man the natives of the islands know more about guided missiles than the natives of the United States The reason stems from a unique tour conducted by the former public information officer at Patrick

He organized a team of officers and men to go through the islands and explain just what was going to be done on a guided missile test range All the safety precautions were emphasized, and everyone was urged to be on the lookout for missiles in a recoverable state

The team took with them a set of charts showing the workings of a missile For live demonstrations of jet propulsion, they took along a supply of balloons and a model missile, rigged to be propelled along a wire by the thrust from a tiny CO_2 bottle

From a salvagable V-1 came a fuselage, and from another missile they snagged a pulsejet engine which fit inside the V-1 body Wings and a Vee-tail completed the operating mockup of a full-size missile called "Liberty's Stinger."

▶ **The Tour**—Thus equipped, the team set out down the island chain At each tiny settlement they stopped, unlimbered the exhibits, and presented their traveling medicine show to the wide eyed audience.

Sometimes they spoke in the village church, sometimes in the town square The balloons rasped erratically above the heads of the crowd, the model whistled along its wire runway, and the charts were explained. Then came the climax when Liberty's Stinger was fired up

A pulsejet in full cry is a devastating sound, even to the man who has heard such devices before. To the natives of the islands, it was a new—and in some cases, frightening—experience But they stuck it out, with the exception of two small boys who got too close one day when the Stinger sounded off The pair leaped into the air, and were running before they came down They plowed through an old board fence in their haste, but kept on right out of sight

▶ **Good Show**—The results of the tour were beyond expectation The team was received with enthusiasm, its arrival meant the equivalent of a local holiday Every inhabitant swarmed down to the beach to help carry the exhibits, and to wave goodbye after the lecture was over

One officer not associated with the team summed it this way

"It was a missionary trip, and it could have made or broken our job here We had to have the cooperation of the people in the islands in order to use the range, and we wanted to show them that we were going to do everything possible to make the operation safe The tour team did a magnificent job"

Flight Sequence

Like most of the other development test centers of the Command, AFMTC's big job is contractor service The entire purpose of the range and supporting sesrvices is to help a missile contractor get the kind of data he wants.

Here, as in other centers, the contractor is the boss; his tests can cover

■ PATRICK

any reasonable ground, and he can ask for—and get—any reasonable support he needs When his test is finished, AFMTC hands him the data and wishes him luck

▶ **Safety First**—Safety of the range is the only consideration which can overrule a contractor's wishes Once the missile is airborne, the Inflight Safety Officers take over, and have the power of destruction over the bird

Similarly, if the range has not been cleared by firing time, the Range Safety Officer can hold the test beyond the contractor's scheduled zero time

▶ **Flight Sequence**—A missile launching program starts when the contractor makes his first request to the Wright Air Development Center for a test

WADC programs the test and schedules it into either Holloman Air Development Center (if the missile is small, short-range, recoverable) or AFMTC (if the missile is large, long-range, non-recoverable) That program is reviewed and approved by ARDC

Project officers at AFMTC meet with the staff of the 6541st Operations Group (Range) under Col Harold Norton to block out a firing schedule Normally they plan one week's schedule on a firm basis and the following week tentatively, to be able to take care of any aborted tests the first week

Alternate firing periods are figured in, during which simulated runs are scheduled Instrumentation plans are established according to the needs specified by the contractor

The official paperwork—Missile Test Request—is used to get the missile to AFMTC for firing, the flight plan is developed and all down range stations are brought into the picture through the communication chain

▶ **Fox Day**—The firing date (F Day) is established after the flight plan has been reviewed and approved by the support groups On F-minus 1, operations receives reports on range readiness from the down range stations by direct teletype connections

Work begins at the launching pads around midnight before the firing Although the best hours for launching at the Cape are the last three hours of daylight—because the sunlight streams down range instead of into the eyes of observers and optical instrumentation—the reliability of pre-flight procedures is still not high enough to permit precise scheduling

The usual routine is to work through the night before, counting on an early morning shoot—the next best time Then if delays come into the program, they can be compensated for by stretching the flexible launching schedule into the early evening

On F-Day the contractor establishes

the count-down procedure, knowing how long each step of the pre-flight check takes The communications links are checked out, and range clearance is begun.

▶ **Air Support**—From the runways at Patrick stream about a dozen aircraft, a mixed group of Boeing B-17 and B 29 converted bombers for range clearance and guidance, and North American F-86s for chase and guidance and—if necessary—for destruction of the bird

The B 17s cruise above the wedge-shaped range clearance area looking for ships and small boats By radio and by powerful loudspeakers on the aircraft, these "Polly" planes pass the word on clearing the area Other B 17s and B-29s check on aircraft clearances, some monitor interference control for the missiles under command guidance from the ground

Back at the Cape, technicians complete each step of the pre flight check on schedule, although not necessarily on time. This results from a holding procedure superimposed on the count-down, if X-minus 10 minutes comes up and fuel tanks aren't yet filled, for example, time stands still at X-10 until the tanks are filled Then the count down progresses

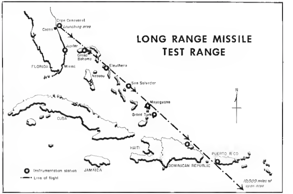
▶ **Firing**—With range and launching pad clear, the missile is ready for firing At X time, the controller at the console inside the blockhouse closes the firing circuit and the missile blasts off the pad.

Takeoff is photographed by a ring of special cameras, and the primary data is filmed during the first few seconds of flight Camera coverage of the launch extends to an altitude of about 4,000 ft and picture clarity and accuracy will give missile position within three or four feet

Immediately the Inflight Safety Officer assumes control He is told by automatic plotting of radar data just where the missile is inside the range. Skyscreens check the radar plots by visual observation through a gridded telescope field, the operators report back to Inflight Safety

If the missile begins to edge toward the range limits, the safety officer will generally tell the contractor to get it back on course This failing, the safety officer has a try, if the missile still deviates, he blows it into chunks by a destructor mechanism actuated by the firing key which he holds during the entire flight

▶ **Flight Data**—Right after launching special modifications of the Askania phototheodolite make a record of the missile angle and elevation on film These pictures, combined with baseline calculations (for triangulation) give the missile position within 50 ft out to a slant range of about 15 miles.



Mid-course flight is monitored by radar, the SCR 584 modified to record on a data box If there is a good beacon in the missile, tracking is easy out to a slant range of about 150 mi with an accuracy of about 200 ft in space

With skin tracking, the slant range is less depending on the target Actually the mid-course data is not too critical, only the general flight path is of interest.

At the impact point at a downrange station, technicians manning the radar and phototheodolites measure missile performance as it dives toward the water The radar acquires the target by data passed on from computed parallax data, giving the position of the Grand Bahama radar based on the radar at the Cape

▶ **Data Handling**—The ultimate goal is a completely automatic range, insofar as data recording and reduction goes Right now, tracking data is taken manually and punched on tapes to be fed into the SEAC computer of the Bureau of Standards Telemetering data runs through automatic reduction equipment from the original tapes and is then fed to the computer

The data belongs to the contractor, but in this learning stage for both range and contractor personnel, the data is shared to evaluate range instrumentation as well as the missile

A data report for a specific flight is prepared by the 6541st Operations Group, and the 6555th Guided Missile Group writes a summary report of each week's firings

At the end of each phase of missile flight test, the GMG also publishes a review of the phase

Cameras

Col Norton told Aviation Week some of the details of the specialized camera installation used to track the missile at launch

▶ **Recording Ring**—The launching pad is ringed with cameras for photographic coverage of detailed phases of the takeoff Position, velocity and attitude are recorded on film from points to the right and to the rear of the missile and from one quarter to one-half mile away

Askanias and Mitchell cameras are three to five miles away, and in some instances as far distant as nine miles Three theodolite stations are set up, one at the north and one at the south end of the Cape, and the third at Patrick AFB

GSAP (gunsight aiming point) cameras are mounted on the missiles sometimes to photograph some detail

Col Norton said that these cameras were the primary source of data

- **Clark ribbon frame**, with a picture about five inches wide and one quarter inch deep, aligned so that the aperture is parallel to the line of flight It is used primarily to get acceleration, velocity and position during the launch phase Speed is 120 frames per second, but it can do 600
- **Hulcher ribbon frame**, essentially the same as the Clark but with a much wider field of view With this camera, operators can increase the area of coverage and can get data if the missile leaves its pre selected takeoff path
- **Mitchell highspeed** motion picture camera is used for tracking the missile from takeoff until it disappears and is useful for giving attitude data It is also used during terminal phase into the impact It has a 35 mm frame size, lenses with focal lengths from 20 to 180 inches, can be used in a fixed position or for tracking Normally run at 64 frames per second in color, it can operate from 16 to 600 frames per sec
- **Fastax highspeed** motion picture camera is used for closeup work in color It has been useful in studies of flame propagation missile separation from the launcher and umbilical cord pullaway It runs at 600 frames per second on 16 mm film, and empties the container in about three seconds

History

Selection of the Cape Canaveral site was the recommendation of the Committee on Long Range Proving Ground,

■ PATRICK

named in 1946 to study the best location for such a range There were alternates considered, the Navy site at Pt Mugu was one and the Gulf of California was another.

▶ **Why the Cape?**—But the Cape was picked because its climate was suitable for all year operation and because the area was one section of Florida left untouched by the great real estate boom of the Twenties. Land was cheap, uninhabited and isolated, safety and security would be easy and economical.

Another factor weighing heavily in the final designation was the abandoned Banana River Naval Air Station nearby, a prospective base of operations for headquarters, support aircraft, etc.

The Joint Research and Development Board approved the Committee's report in July 1947 and in December, the Air Force was told to get going on the development of the range.

▶ **Organization**—A group with equal representation from Army, Navy and Air Force, and directed by Maj Gen William L Richardson, now commanding AFMTC, started the actual work to back up Board recommendations

First they had to become experts in foreign affairs There were treaties to be made with the governments of the United Kingdom, the Bahamas, Jamaica, Dominican Republic and Puerto Rico

Col H W Norton
Commander, Range Group

Then they had to activate interservice channels to bring in experts from the entire military establishment

By mid 1948, NAS Banana River was transferred to the Air Force, and rehabilitation of that base began

▶ **Starting Up**—By October of the following year, work had begun on the Cape site and island stations The range was then known as the Joint Long Range Proving Ground, to be operated jointly by Army, Navy and Air Force under administration by USAF

This arrangement continued until June 1951, when the range was redesignated as the Air Force Missile Test Center and placed under the Air Force alone. At the same time, the Navy was given complete control over Pt Mugu, Army received control over the White Sands plus Holloman range

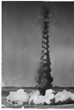
▶ **Today and Tomorrow**—Actual missile firings on the range today are rare, but so are actual missiles

This fall, long-range firings will begin over distances of at least 500 miles, a goal promised as far back as 1949. There are plans to fly missiles as far as Grand Turk, turn them and fly them back to the Cape for a total range of about 1,500 miles

So step by slow step, missile progress follows the extension of the range "If this range is to be of any value, we've got to stay ahead of the missile business We always have to have a longer flight line than any contemporary missile can travel," said one officer

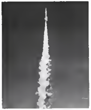
"Today it's a piddling 200 miles; this fall it's going toward the 1,000 mile mark. Next stop? Don't forget the string and the globe."

1 AEROBEE, high altitude sounding rocket, is serviced with propellants.



AEROBEE rides steel rails till it . . .

CLEARS launcher. Smoke identifies . . .



BOOST phase of first seconds. Then . . .

SUSTAINER rocket takes over for flight.

2. IT IS RAISED to vertical inside steel launching tower. Rocket is fired from . . .

3. BLOCKHOUSE, linked to launcher by cables in long concrete trench.

Holloman Tests Missiles and Pilotless Aircraft

Alamogordo, N. M.—North of the Rio Grande, the San Andres and Sacramento mountains rise out of the desert floor in parallel ridges, the west and east boundaries of El Paso del Norte, historic avenue between Mexico and the United States.

Halfway up the pass, the billowing dunes of the White Sands National Monument encroach on the Tularosa basin. A little further north is the greenish silica circle in the desert that marks forever the site of the first atomic blast set off by man.

This is the geography of the region around Holloman Air Development Center.

The rugged country around Holloman matches the rugged job of the Center—the testing of missiles, pilotless aircraft and various types of associated equipment.

▶**A Busy Base**—Through the indigo skies over the base have flown, floated—and flamed—the gamut of aerial research tools. Free balloons have hung at altitudes approaching 100,000 ft., and drifted in jet streams to Norway and Algiers and the Atlantic. The Aerobee research rocket has blasted upward at supersonic speed carrying monkeys and mice 200,000 ft. above the desert crust, Martin's Matador and Northrop's Snark have orbited up along one ridge and down the other.

Holloman is a busy base. Visitors are not aware that missiles are being fired or drones launched while they are at the base. For safety, launching sites are remote and widely scattered over the desert.

But like the circus, Holloman is a performance where something is happening in every ring.

During July more than 60 firings were scheduled, not counting those run on the rocket track.

▶**Problems**—There still are many jobs to be done at Holloman. "Right now our projects outstrip our facilities," Col. Don R. Ostrander, HADC commander, told AVIATION WEEK. "We didn't really get rolling technically until fiscal year 1952."

"Space is our problem—we're very crowded—and we're strapped in the missile test group on personnel," added Lt. Col. Harry F. Boone, deputy commander of the Guided Missile Test Group.

Lack of personnel will be helped by a group of 26 German scientists, recruited last summer. In charge of the recruiting was Dr. Ernst A. Steinhoff, formerly with the Army Ordnance missile team at Ft. Bliss, and before that head of the Steering and Control group at Peenemuende in Germany.

Steinhoff is head of the Technical Analysis Division which will absorb all the Germans. Reason for the recruiting was two-fold. The Germans had certain technical competence, and engineers are hard to get.

▶**Why Here?**—Like some other ARDC centers, Holloman was located because of the peculiar geography. There were other Air Force bombing ranges available at the time Holloman was picked as the site for missile work, but there were disadvantages to many of them.

The whole length of this range is bordered by mountains East and West, these serve as a natural barrier to the range and their tops are dotted with down-range instrumentation stations. Far to the north, more mountains rise to block off that boundary of the range. This basin is like a gigantic bowling alley along which missiles can be fired and controlled.

Directly below the southern border of the Holloman area is the Army Ordnance White Sands Proving Ground, site of most of the ex-German V-2 firings in this country, and crater-dotted by impacts of hundreds of test rounds. Still further south is located the Army's Ft. Bliss Anti-aircraft Test Range.

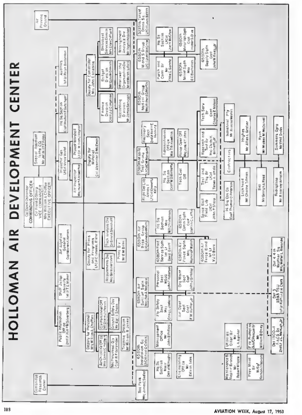
▶**Joint Effort**—These three ranges—Holloman, White Sands and Ft. Bliss—are now consolidated into a single strip 128 miles long, 38 miles wide, operated by a joint Air Force-Army committee.

Odd buildings are scattered through the desert area. They are concrete blockhouses, strong points for missile launchings, or telemetering vans or other instrument housing. Nearer the base is a high board enclosure to protect the Moby Dick balloons at launching. In the technical areas there are large hangars with contractors' names—Lockheed, Ryan, Hughes, Bell, Radioplane—painted on signboards outside.

Off to the north, standing alone in the middle of the valley, is Tularosa Peak. Its flattened top is man-made,

Col. Don Ostrander, commander, Holloman Air Development Center . . . ordnance expert . . . born Stockbridge, Mich., 1914 . . . graduated U. S. Military Academy, 1937 . . . began military career in aviation ordnance serving at Ft. Bliss, Langley Field, Aberdeen Proving Ground and Selfridge Field . . . became ordnance and armament officer 8th Fighter Command in England . . . developed "droop snoot" P-38 high altitude bomber . . . flew as bombardier on first P-38 "droop snoot" mission over Europe to test Norden bombsight modified for fighter bomber use . . . postwar, served in armament laboratory, Wright Field . . . became special assistant to the commanding general, ARDC, at Wright-Patterson AFB . . . took command of Holloman June 5, 1952.

HOLLOMAN AIR DEVELOPMENT CENTER



chopped off and leveled for instrumentation. Buildings and tons of recording equipment now crest the peak and make it one of the most completely instrumented areas in the United States.

▶ **Coordination**—All instrumentation on the range is the responsibility of Army Ordnance. The development of new or special kinds of instruments is also a task performed by the Army, although the ARDC development centers might get into the job at different levels. There is liaison and coordination between the instrument makers and the instrument users.

- Land-Air, Inc. operates the test instrumentation under contract.
- Range safety is handled by a joint AF-Army committee.
- Missile recovery is the province of Army.
- Missile scheduling is handled by a unit within the Missile Test Group. They consider requirements jointly with Army; there is considerable give and take with the staff of the White Sands Proving Ground.

▶ **Link to AFMTC**—The connecting channel between the work of the Holloman Air Development Center and that of the Air Force Missile Test Center at Patrick AFB is determined primarily by the type and status of the particular missile.

Currently accepted policy says that Holloman will worry about any recoverable missiles or test vehicles and short-range weapons. The AFMTC will take over when missiles become "semi-reliable," go on an operational status or are required to undergo long range testing.

"Training guided missile outfits is going to be a tough job," says Col. Ostrander. "We have such a limited number of ranges in this country and their use is heavy enough now."

Another tough job for the Center has been getting and keeping the military and civilian personnel with experience in guided-missile work. Turnover of such people hurts, Ostrander says.

▶ **Helping Hands**—Contractor support is one of the big jobs at Holloman, although it is the last task defined in the statement of mission.

In effect, the contractor moves in as a tenant. Holloman furnishes building space for missile assembly and checkout, and office space for technicians. If the contractor needs airplanes for flight test work or for airlifting a missile from his home plant, Holloman supplies them.

When the missile is ready for firing, Holloman takes over the administrative worries that go with the task. They arrange transportation to the launching site, handle scheduling of the firing with the joint committee. Channels of communication and radio frequencies

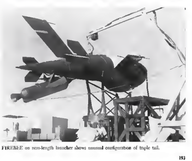
RYAN FIREBEE pauses at the end of launching track for count-down before firing.

BOOSTER blasts Firebee off track and ...

INTO FLIGHT. After boost phase ...

EMPTY RATO leaves Firebee in flight.

PARACHUTE recovers drone after test run.



FIREBEE on zero-length launcher shows unusual configuration of triple tail.

■ HOLLOMAN

are assigned by HADC personnel, they also rule on range safety and missile recovery.

A project officer is fed into the system by Holloman for on the job training. His main task is military liaison and he gets his authority from the contracting officer.

▶ **Hands Off**—Beyond acting as aides to the contractor, Holloman personnel aren't authorized to do anything else. "It's the contractor's missile, and when it's ready to fire, we just stand back and watch."

This hands-off approach is typified by the routine for asking the contractor to make a specific test. HADC can't do this directly; the questioning agency is Wright Air Development Center, and through this channel must go any requests for contractor activity from HADC.

Holloman, however, can use a stop order on a firing and make the contractor wait while the questions are routed to him formally through WADC.

Final task of the base personnel is to report on the firing, although this is not the official report which contains the test data. The HADC report is more on the lines of a summary, with no conclusions drawn from data or observations. The report says whether the missile worked.

▶ **Missile Recovery**—After impact, the Army swings into action with its recovery teams. Liaison aircraft—Cessna L-19s, a Convair L-5 and a Sikorsky H-5 helicopter—scoot along the valley searching the area around the predicted and plotted impact point.

"We fly around 500 ft., generally with a single search plane although sometimes we have used three," said Lt. Robert Hubbard, one of the Army's pilots. "Once we've spotted the impact point, we radio back to the ground parties and circle the area or lead them to the impact site.

"It's not easy to find a missile that's scattered itself over the desert floor or bored its way in. We've flown over an area several times before spotting the missile lying in plain sight on the ground.

"It may be so far from base that the ground parties have to camp out overnight and go on in the morning. We can land anywhere and stay with them or go on back to base and fly out again the next day."

▶ **Retrieving**—Hubbard said they needed a bulldozer on occasion to dig out bombs or missiles, and often there would be a special trailer required to haul the missile back to base. These vehicles are all Army equipment.

One other job done by the group is range safety. They set up road blocks with the radio trailers for air-to-ground communication.

Hubbard is a walking example of the joint operation of the range. He's stationed at Holloman, assigned to Army Ordnance and attached to the Air Force.

Complement of the Army's "air force" at Holloman is five L-19, one L-5 and one H-5.

Research Test Branch

The research test branch, said Maj. Ernest P. Luke, has the job of furnishing three test facilities: the Aerobee rocket, balloons for high-altitude flights and the high speed test track.

Research test branch is divided into operations or test section and an engineering and development section. The latter group handles all electrical and mechanical installations, all electrical development, and all aerodynamic and mechanical problems in the development of new test items.

Capability of the section to do original work is developing now but only the initial stages of such a capability have been reached.

▶ **Aerobee**—One of the most versatile of test vehicles is the Aerobee high altitude sounding rocket (RTV-A-1A), developed and manufactured by Aerojet Engineering Corp. Thirty-seven rounds have been fired out of the tilting firing tower since Dec. 2, 1949.

It is not a cheap program. Each round costs about $20,000 to buy and nearly $500,000 to launch, including everything and everybody involved. Test results from this workhorse rocket have proven its value.

Aerobee is 26-ft. long and most of its slim 1,100-lb. bulk is propellant, piping and powerplant. The small remainder is concentrated in the ogival nose section where instruments, telemeter equipment, fruit flies, mice and monkeys have made the trip to altitude.

▶ **Leaning Tower**—The 120-ft. high steel launching tower is visible from far off. It juts skyward, its red steel truss work tied to a concrete base, and leans permanently one degree to the North. This tilt gives initial guidance to the Aerobee, which has no means of guidance or control once it leaves the tower.

Two legs of the tripod base are on a North-South line, with the northern leg shortened to give the permanent list. The west leg is mounted on a hydraulic cylinder, which serves to tilt the tower through an arc between two degrees East and one degree west. Initial deflections in these directions can compensate for the earth's rotation and wind drift.

▶ **Firing**—Firings are generally at dawn. Aerobee and its booster are loaded into the tower vertically, bearing laterally on

three rails extending the height of the tower

After the conventional warnings and countdown, the booster is fired Initial acceleration of the missile is 14G, and in a split second it is clear of the tower and blasting up In a few seconds the booster has burned out, the sustainer rocket engine in the Aerobee itself has fired, and separation of booster and vehicle takes place

► **Flight Path**—Between 33 and 34 seconds after firing, the sustainer engine has exhausted its propellants By then Aerobee is ripping along at about 4,600 fps, and has passed 75,000 ft

From there on, it coasts to zenith, which depends on the payload and the operation of the engine Peak altitudes run close to 80 miles. With the mice and monkeys inside the Aerobee, 40 miles was reached

Once over the top, Aerobee begins to fall, tail down, towards the earth At about 200,000 ft the tail cone is blown off This makes the rocket unstable, it begins to tumble and the drag is increased, slowing its plunge The body free falls to about 20,000 ft, where the nose cone is blown off That section, which contains the instruments and recorded data, is lowered to the ground by a gaudy orange and black parachute, to make for easy spotting by the Army recovery groups

► **Free Balloons**—The original purpose of free balloon flights at Holloman has been expanded to a large collection of research projects.

In 1950, the idea was to use the balloons as a pre-flight checking vehicle for the expensive rocket instruments that had to work right the first time Now balloons carry payloads of several hundred pounds to altitudes around the 100,000 ft mark, and investigate a variety of altitude phenomena

The many tasks performed by these versatile vehicles and the manner in which the organization of the balloon flights cuts across almost all of the ARDC centers sets them apart as unique tools

► **Rocketing Railroad**—The original purpose of the supersonic test track at Holloman was to launch guided missiles, such as Northrop's Snark, and target aircraft But like the balloons, the original purpose has since been swallowed up in a formidable list of tests that can be performed conveniently and cheaply with the track.

Special test vehicles, called sleds, ride the steel rails on stellite slippers, carrying equipment down the 3,600-ft run.

Space Biology

Five hundred fruit flies hold the current free-balloon altitude record, set

during routine flights to study radiation effects.

They are the subjects in a program conducted by the Space Biology lab at Holloman to determine effects of primary cosmic radiation.

Reason for the studies is that manned flight is beginning to reach the altitude belt—70,000 ft. to 90,000 ft.—where cosmic ray intensity is appreciable. It is necessary to determine what those rays will do to man. Current scientific opinion varies from "some effect" to "possibly lethal."

Fruit flies are used because they are so well known genetically. Their life cycle is only two weeks, which is brief enough so that a short period of time after the flight will produce enough offspring and successive generations to make statistical studies.

► **Flight Details**—The general research program and details of the tests were explained by Maj. David Simons, a former flight surgeon now assigned to the work of the laboratory.

Simons explained that primary radiation is made up of the stray nuclei of heavy elements like iron, carbon, oxygen and nitrogen. These can't be duplicated at ground level, although the lighter nuclei of hydrogen and helium can be to some extent.

The chief field of interest is in the "bullet" effect of the cosmic particles. These particles can rip through tissue and out again without doing much damage. It is when they begin to slow down that they get dangerous, because radiation is strongest when the particle has nearly stopped.

When these nuclei begin to slow down well below the speed of light, they collect electrons and ionize at a high rate. The net result—as far as tissues are concerned—is that they are hit with a cylinder of highly ionized material about 100 microns in diameter and a very few millimeters long. This is the "bullet."

► **Gene Damage**—The particular study now under way at Space Biology is to find out whether or not the bullet causes any particular damage to the genes of the flies. (Genes are the units of inheritance, they determine presence or absence of such characteristics as black bodies or red eyes in successive generations of the flies.

The bullet can cause both genes of the fruit fly to split, and a phenomenon known as translocation takes place.

Simons said that translocation was something like a double-cross in tree grafting. You graft a limb from tree A to tree B, and a limb from tree B to tree A. The fruit you got from tree A would be mostly fruit A with a little fruit B thrown in, the opposite would be true for tree B.

This program has been running for more than a year, and countless male flies have made the trip aloft, have been recovered and mated to virgin females for genetic studies. It is definitely not encouraging to look at the charts of inherited characteristics plotted from these test runs and to see long lines drawn through an occasional generation. The lines are marked "Lethal."

► **Fly Carrier**—A bright orange sphere is the balloon gondola on these tests. Inside the zippered canvas covering is about three inches of Fiberglas insulation and an aluminum sphere. Four screened cages are supported inside the sphere on plywood bulkheads, and in these boxes, of course, are the flies, 125 per box.

No oxygen is added to these containers for the flights, but Simons said that they do throw in some soda lime to keep down carbon dioxide.

Almost all of the flights use balloons for the test vehicles, because—at the lower surface of the cosmic ray layer—a long exposure is necessary to make sure that some flies will get hit by the stray nuclei. During a 24-hr. exposure, Simons said, only one or two flies are apt to get struck.

► **Recovery Problem**—The maximum transition from primary radiation to secondary—which occurs when a primary collides with another particle—is at about 70,000 ft., but Simons said that flights have to go to 90,000 ft. to get any kind of results. He would like to get exposures of at least 72 hr. duration in order to speed up the data gathering.

Simons explained that the problem in all the tests is recovery of the container; there is some difficulty yet in working out the tracking of the sphere.

On the use of rockets, Simons said that they were used occasionally for the studies of excessive or zero gravity, but that the short duration at altitude made them undesirable for radiation studies.

Drones

Part and parcel of the development of any weapons system is the parallel development of targets to prove the system. At Holloman, among the several types of target drone aircraft two are available in quantity: Radioplane's OQ-19 and Ryan's Q-2 Firebee.

The OQ-19 is the latest in a long line of target drones built by Radioplane, originally the property of actor Reginald Denny and now owned by Northrop. Perhaps more than any other contemporary aircraft, the OQ-19 owes its success to long backgrounds in model building and flying on the part of its developers.

► **Life Span**—The best illustration of

PLANNING THE RIGHT ANSWERS

The complexity of modern air defense—extreme aircraft speeds, highly complex weapons, new combat strategies, the advanced state of today's technology—poses serious problems for the scientist and engineer.

One significant solution lies in the extensive use of airborne automatic equipment, including electronic digital computers, to augment or replace the human element in aircraft control.

At Hughes Research and Development Laboratories each problem is attacked basically, beginning with systems planning and analysis. This consists of an exhaustive examination of the requirements of a problem, together with an evaluation of the best means for satisfying these requirements. The objective is to design the simplest possible mechanization consistent with a superior performance.

These techniques, employing many special talents, are responsible at Hughes for the successful design, development *and* production of complexly interacting automatic systems for all phases of electronic control of interceptor navigation, flight control, and fire control. Similar accomplishments may be pointed to in the guided missile field.

Methods of systems planning and analysis responsible for achievements in the military area are also being applied at Hughes to adapt electronic digital computer techniques for business data processing and industrial controls.

HUGHES

Research and Development Laboratories

CULVER CITY
LOS ANGELES COUNTY,
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ADDRESS:
SCIENTIFIC
AND ENGINEERING
STAFF

Dr. E. C. Nelson (left), Head of Computer Systems Department, and J. H. Irving, Head of Systems Planning and Analysis Department, discuss a problem in the systems planning and analysis stage.

PHYSICISTS AND ENGINEERS

Hughes activities in the computer field are creating some new positions in the Systems Planning and Analysis Department. Experience in the design and application of electronic digital computers is desirable, but not essential. Analytically inclined physicists and engineers with a background in systems work are invited to apply.

ASSURANCE IS REQUIRED THAT RELOCATION OF THE APPLICANT WILL NOT CAUSE DISRUPTION OF AN URGENT MILITARY PROJECT

this is the launching technique. Often fired from a catapult or even one of the rocket track sleds, the OQ-19 has recently been flown off the ground on a control line

▶ **Firebee**—Ryan's Q-2 drone was launched initially from a modified Douglas B-26. Later techniques have made it possible to ground-launch the Firebee using a solid-propellant Rato unit.

Most of the Firebees now operated are powered by the Fairchild J44 turbojet, a lightweight engine of monocoque design

A few of the Firebees have been flown with French Marbore jets which have a lower fuel consumption.

▶ **Engine Mounts**—The Fairchild engine as mounted in the Q-2 needs no extra tailpipe other than that supplied with the engine. The Marbore has a long and angled tailpipe to compensate both for the engine's shorter length and the direction of flow through the turbojet.

"Getting at the power plant for maintenance or removal is a cinch with the cowling design Ryan developed," said Walter Andre, civilian engineer in the drone section.

A wedge-shaped piece lifts out of the upper cowl about two feet behind the nose. At the pointed ends of this wedge are hinges with their hingeline across the fuselage from right side to left. The mechanic unlatches the cowling at the rear of its lower surface, and the whole cowling swings down, rotating around the hinge line until the wedge-shaped open segment is closed.

▶ **Recovered Birds**—A line of Firebees in various states of teardown and assembly indicated the endurance of "birds" which had already flown and been recovered. Their red noses bore white stencils of the Firebee under a parachute for each successful recovery. Top score for any drone in the hangar was nine recoveries.

Andre said recovery of the bird has been highly successful. Capt. Jay Smith of the Parachute Branch said that the Firebee was a good example of a fine installation of a parachute recovery system.

Only two of 71 flights cracked up instead of floating down under the silk. On the two that failed, post-mortems uncovered the reasons and there aren't likely to be any more failures from that cause.

Porochutes

If there is a parachute problem, the chances are that Capt. Jay V. Smith can help. He is head of the Parachute Branch at Holloman, and his group is set up to manufacture, repair and test

■ HOLLOMAN

chutes from 10 in in diameter to 150 ft across

Do you want a reliable barometric pressure switch? Smith's outfit has one. He says that it is a little too heavy and a little too complicated for personnel chutes right now, but it works every time.

► **They Find Answers**—Do you need to know the drag characteristics of a WAKO spherical chute? Smith's group can probably dig out the figures

Are you stuck for space in the chute compartment? Try pressure packing, an innovation in technique for squeezing out all trapped air during the packing process

Do you want some design advice for that recovery system for your next missile? Smith makes a fervent plea to allow for altitude enough and space enough to accomplish the task.

► **Branch Mission**—The job of the parachute branch is to provide service for the contractors, to install and modify parachute recovery systems, and to conduct tests to improve the systems

To accomplish this job, the branch is scheduled to make about 30 drops per month, based on 22 working days per month But Smith said that aircraft availability cuts that figure down by as much as 25%.

Two general types of tests come under the work schedule of the group

- **Proving tests** of a new item in a system, a recovery modification or a functional component test
- **Service tests** of parachutes before they are used in a recovery system, or any new or repaired chutes

They have developed a standard container for chutes by modifying several general-purpose bombs. They take a bomb, chop off the portion behind the rear mounting lug and replace that portion with a sheet-metal tailcone. By using the nose shapes from 500-, 1,000 and 2,000 lb. bombs, they can get a range of containers that will handle loads from 240 to 3,000 lb.

► **Instrumentation**—The container is rigged in the bomb bay or under the wing of one of the drop aircraft—Douglas B-26, Boeing B-17 and B-29, or Douglas C-47—taken to altitude and dropped

Instrumentation is GSAP cameras to photograph the deployment of the chute, and accelerometers to measure the opening shock and impact shock. Base instrumentation gives the space-time relationship during the drop

In spite of the 600 year history of the parachute, there are plenty of problems which time has not solved. Smith says there is as yet no catch-all parachute system, each type has to be developed on an individual basis. This

■ HOLLOMAN

means time, and what seems like duplication of effort Smith is the exact antithesis of the guy who has a book and doesn't want another; parachute systems come in libraries

There isn't any system big enough for the recovery of really heavy objects, Smith pointed out Right now they use multi-stage recovery where one parachute is used to slow the package down and others are used for the letdown

History

Many an Air Force pilot today remembers lifting B 17s, B-24s and B 29s off the runways at Alamogordo Army Air Field This was the original name of the base that is now Holloman

The field was deactivated at the end of the war

▶ **First Missile Work**—Meantime, the Air Force had been making its first steps in the direction of guided missiles at the Air Materiel Command base at Wendover, Utah

By the end of 1946 the old bombing range at Alamogordo was selected as a good missile test area The available land was about 64 miles long and 38 miles wide, and sparsely populated

So Col Paul Helmick, who had been in charge of the First Guided Missile Group employed overseas for combat, was sent to Alamogordo in charge of a field party to start the base missiles activities Other airmen and officers were transferred from Wendover, which was being closed, and Holloman began to grow

In six months—on Sept 17, 1947—the first test round was fired

▶ **Now Holloman**—One year later the base was renamed Holloman AFB in honor of Col George V Holloman, a pioneer in the guided missile research field

When the Air Research and Development Command was formed in 1951, the base was taken under the Air Force Missile Test Center at Patrick AFB, Fla, and was known as the 6540th Missile Test Wing In September 1952 the base was taken from AFMTC and redesignated the 6580th Missile Test Wing A month later, Holloman was named one of the development centers of ARDC and the range was consolidated with those of the Army in a joint cooperative

North of the Rio Grande, between the enclosing arms of the San Andres and Sacramento mountains, fly the shape and substance of tomorrow's missiles

Now, as in the past, pioneers are traveling the length of the historic pass to the north

FIREPOWER demonstration showers targets with napalm, rockets, bombs and bullets Lockheed F 80 roars over wrecked vehicles as . . .

Center Tests USAF Armament Systems

AFAC gives developers of new weapons systems a place to proof-test their work, get the 'bugs' out of components.

Eglin AFB, Fla—"Without armament, there is no Air Force."

Emblazoned in offices and hallways, on walls and bulletin boards, these seven words by Lord Trenchard (regarded as the father of the Royal Air Force) summarize the philosophy, the job definition and the attitude of the Air Force Armament Center, located on Choctawhatchee Bay on the Gulf of Mexico

- **As a working philosophy**, the sentence expresses the position of armament in the complex picture of contemporary aerial warfare
- **As a job definition**, it draws the broad outlines within which officers, airmen and civilians work at this Center
- **As an attitude**, it reflects the opinions of the armament experts, starting with AFAC's commander, Brig Gen Edward P Mechling, and extending right on down through the ranks

▶ **Analogy**—Unlike their medieval counterparts, these armorers don't forge any weapons themselves Their work is today's equivalent of the proof test, used to satisfy the customer of the Middle Ages as to the adequacy of his armor

In effect, AFAC runs a shooting gallery It operates the range, gives the customer a place to stand and bullets to shoot It marks his targets, and gives him the results

Right now, it is not a very ornate shooting gallery It is not even complete AFAG is a very busy proprietor, trying to keep as many customers shooting as possible, while building an addition to the gallery next door and setting up new and different targets in the original range

But within the next eight months, the Center will have completed the lion's share of its facilities, and will be able to show the biggest change yet in capability

At that time, AFAG will be well along in its plan to develop an all-weather capability for testing any armament system or any of its components.

▶ **Not Just the System**—Almost every time the phrase "weapons system" is spoken around this Center, it is followed by "and its components" That is a clue to the stress which has been placed upon sub items of a system, and not on the system alone

"The weapons system concept can't be fully successful unless it's based on the availability of tested components," Gen Mechling told AVIATION WEEK

"A weapons system has about a five year lead time, and the initial choice of components must be made on the basis of some experience. So it is important that the full scale of component developments be sponsored and adequately tested for the state of the art so that systems engineers will have suitable equipment and test components

"It's true that everything in the component line will not be used, but we must test sufficiently Right now we are creating a technical capability and capacity, our ability will contribute to the success of the weapons system plan

"Remember that testing has to be done in time to be effective"

▶ **War Baby**—The Air Force Armament Center was really started by the minor multitude of weapon failures during World War II. Because there had been no central test facility set up by the Army Air Force, much new armament used during the war years had been committed to production ahead of time

The AAF was embarrassed by being forced to rework or refit equipment on aircraft, and also lost money and precious time

Out of these failings grew the realization that an armament test center would be a valuable asset

Both the Air Staff and the Air University made studies of the problem. Some of these were aimed at opening a new test area but somebody discovered that—at that time—Eglin AFB near Valparaiso, Fla, was not being utilized to capacity

The decision to put armament testing in with the work of the Air Proving Ground at Eglin was made by Gen Vandenberg, then USAF Chief of Staff, in early 1949

One reason behind this decision was the availability of the facilities of the APG Charged with operational suitability tests of all AF armament, the Air Proving Ground requires test ranges which are the same as those required by AFAC The only difference between them is that generally there is more instrumentation required for an AFAC mission than for an APG mission

Construction began during fiscal year 1950 In December 1951, the Air Force Armament Center was officially designated, placed under the Air Research and Development Command and Gen. Mechling was named commander

▶ **Advisers**—There were two deterring factors First, experienced people to form a strong nucleus were not plentiful, second, the prestige of armament in the Air Force was pretty low

Immediately after his appointment to the command of AFAC, Gen. Mechling—with 18 years experience in Army Ordnance before transfer to the AF—set up a Technical Advisory Group of 20 consultants

These men—armament specialists from industry and technical schools—advise Mechling on modification or extension of the Center and its organization. They meet about annually as a group, individual members may be asked for specific answers to special problems

As an example, a Group member might be asked to comment on the validity of conclusions drawn from certain test data, another might be asked to recommend the most practical method of utilizing the range data.

Although the organization calls for a full time executive director of the Group, there was none as of mid July

Brig Gen. Edward Pont Mechling, Commander, Air Force Armament Center ordnance expert who transferred to USAF when it became a separate service born Knoxville, Tenn. graduate U S Military Academy 1927 graduate of Army Ordnance school bachelor s degree in mechanical engineering from Massachusetts Institute of Technology served as ordnance officer with 8th, 12th and 15th Air Forces in Europe during World War II deputy director of armament in USAF Hq 1948 51 assigned as deputy director armament Hq ARDC before taking command of USAF armament center author of field manual on electric and gas welding wrote articles on ordnance and logistics awarded Legion of Merit and Air Medal

Gen Mechling wanted to get the best person available, but was not in a great hurry to fill the job until he was satisfied personally with the prospective candidate

▶ **Advisory Group Members.** Current roster of the Technical Advisory Group comprises these armament experts

Dr H H Bailey, Bell Telephone Labs, R R Beachler Jr, George Bussiere, and W E Swanson, all of North American Aviation, Inc., Dr C S Draper and Dr J P den Hartog, Massachusetts Institute of Technology, F W. Godsey, Jr, Westinghouse Electric Corp, Dr Walter Bartky, University of Chicago, Henry A Berliner, Engineering Research Corp, Homer H Ewing, E I du Pont de Nemours & Co, Inc

Also, Col. R. L. Goetzenberger, Minneapolis Honeywell Regulator Co, Dean L E Grinter, University of Florida, Donald B Houghton, the Franklin Institute; Dr Norman G Peterson, Rand Corp, Roderic M Scott, the Perkin Elmer Corp, Oram C Woolpert, MD, Ohio State University Research Foundation, H T Hokanson, General Electric Co, Col H N Marsh, Hercules Powder Co., Inc, Joseph Pinsky, Illinois Institute of Technology

▶ **Circular Circuit**—Armament is a merry go round Requirements lead to development, then testing Procurement follows, and then a period of service life. The experiences learned here lead to new requirements, and the carousel goes round and round

At four stations of the circular path, AFAC has a chance to grab for the brass ring

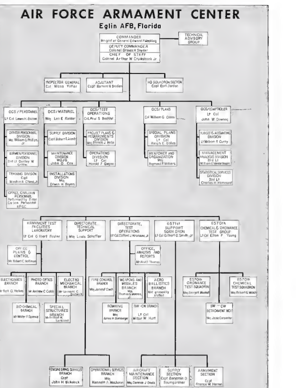
- **In the development phase**, it supports the contractor and tests components of the final system
- **In the testing phase**, the system and components are evaluated as insurance before entering an all out procurement program
- **During procurement**, the armament system, the tactical aircraft and the pilot are evaluated together as a weapons system
- **During service life**, unsatisfactory reports may come in on the performance of an item in combat; inservice testing is the result

All these tests feed back into the development circuits, and, coupled with changes in the state of the art and practice in tactics, help determine future requirements

▶ **The Channels**—These are the steps between ideas and tests in the present development of weapons systems

- **Development Planning Objectives** are the prime movers These originate in the office of the Deputy Chief of Staff

RED BIRD is sweptwing tow target modified from straightwing version at rear



for Development, HQ USAF, and rise out of continual reviews of the state of the art in aerial warfare. These documents lead to:

• **General Operational Requirements,** which define in outline a weapons system or a component GORs go to HQ ARDC, where a solution is proposed, the package of GOR plus whatever help can be added is forwarded as a:

• **Design Study Directive** to the proper Centers for study The Centers make up their version of the proposal, which must be approved at HQ ARDC and HQ USAF before work can start That document is called a:

• **Development Plan;** approval of it constitutes the authority to go ahead and means money is set aside for the project.

"About here is where we get into the act," said Col Paul S Bechtel, Deputy Chief of Staff, Test Operations, for AFAC. "My office is responsible for acceptance, programming, planning, control and reporting of all test programs We work with the Deputy for Plans here all the way through.

"We get in the program as early as several years ahead of the tests, when Wright Air Development Center is working out the Development Plan. We help write the test annex to the Plan after WADC has laid out the test objectives

"We choose the type of test and techniques, and plan ahead so that once the hardware arrives, we can start work," Bechtel added

▶ **Second Phase**—Development type testing, usually called Phase One, is not the job of the Center AFAC work starts in the second phase of engineering evaluation, when the contractor brings his weapon down to the Center to use its facilities

The Center will test in Phases Four, Six and possibly Five, it is also possible that all six phases of tests may be done on a particular item

In general, AFAC tries to monitor the development phase by watching tests while the contractor runs them, in like manner Center personnel work with Army Ordnance. They might handle special applications or special aspects which would put the Air Force in the Ordnance act

Any minor troubles which can be fixed with a minor change are handled at the Center to keep from interrupting the test program If some major trouble appears, the item goes back for development work The Center will recommend changes to the Armament lab at WADC or request that the project officer come down and look the situation over

"Right now we're only doing a little bit of contractor support," said Bechtel

EGLIN

"We'd like to have them come down and get a little extra insight into development problems, whether or not they've got anything to test. We expect that contractor support will grow as the word gets around on the facilities we have."

▶ **Procedures**—"It might be easier on a contractor if he comes here first for preliminary discussions," said Maj. E. J. Hale, head of the Project Plans Division under Col. Bechtel. "Then he makes the formal request through the project officer at WADC."

As in other Centers, there are no charges to the contractor for the use of the facilities, costs are budgeted as part of the normal operating expense of the Center.

Final data may be widely distributed—in the case of Phase Two tests—or may go only to the specific contractor and the military. "Contractors' rights are respected," said Hale. "We may reduce the data for him, and we'd like to keep copies because we have to be able to make technical comments that are well founded."

Hale explained that human factors in test programs are taken into account by using more than one pilot. "We get a pilot through routine channels," he said. "He may get checked out at the Air Force Flight Test Center for special deals first, but usually he comes in here. We do our own training, and end up with engineering pilots."

Pilots from the Air Proving Ground Command are encouraged to come across the street and observe or fly.

▶ **Climate and Problems**—"The climate doesn't hold us back much," said Lt. Col. L. E. Winebrenner, Deputy Chief of Staff. "We can bomb from any altitude about 50% of the time and do most of our test work 85% of the time.

"But we've got problems of location," he added. "When APG first came down here, there was practically nothing. They could bomb and shoot all they wanted. In 1936 you couldn't find your way through the swamps, streets weren't even paved around here until near the end of the war. Now look at it—the whole area has built up and they've got towns and paved roads.

"Fisheries are getting to be a range problem. If we want to extend out over the Gulf, we're going to be right over the area that supplies most of the red snapper and lots of the shrimps and that's a big industry.

"Now the air is getting so full of radio, it's another big problem getting the communication channels squared away. You can see the need for secure communications around here," he said.

▶ **Development Program**—The Center is now building toward the goal of an all-weather, 24-hour test facility. By the end of next spring, the bulk of the planned instrumentation and construction should be finished.

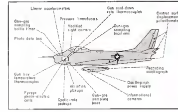
This buildup has been laid out in three steps.

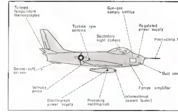
- **The first** was to get the ranges in limited operation while the buildup was progressing, and to get a headstart on the special kinds of instrumentation that would be needed later.
- **The second step** is construction of the major technical facilities—three buildings and six ranges—needed to make the Center capable of fulfilling its basic mission.
- **The third** will put the finishing touches on the Center and give it all-weather capability by adding precision electronic instrumentation to the optical systems that make up the bulk of the data gathering equipment now.

Until the buildup is complete, AFAC will continue to use some ranges jointly with the Air Proving Ground Command, and some of its own ranges at a capability level somewhat below the planned ultimate.

▶ **Completed Center**—The six ranges to be completed in the second step will shape up like this:

- **Precision bombing range.** This range will study one side of the bombing problem—the characteristics of bombs and bombing systems. Data gathering will start at the release point and follow the time history of the system until burst or impact.
- **B line range.** This is a laboratory to study the other side of the bombing problem—the value of the aircraft as a bombing platform. Instrumentation based on shoran (short range navigational radar aid) will pinpoint the position of the drop aircraft within five feet in space at all altitudes and speeds. From this kind of data will come better computers for bombing systems.
- **Air-to-ground rocketry and gunnery range.** Fire-control systems will be put through their paces on this range, designed to take gunnery, rocketry, skip, dive and toss bombing missions with equal ease. The data from test runs will be used to determine magnitude of the several factors that cause dispersion of projectiles.
- **Rocket ballistics range.** Static testing





INSTRUMENTATION for typical armament system test as installed in NAA F-86 Sabre.

of armament systems as mounted in aircraft will be the big job of this range. The damage potential of armament will be determined during the testing program.

• **Moving-target range.** Tactical weapons will be the big users of this range, intended to evaluate forward-firing systems against the kinds of moving targets encountered in battle.

• **Pattern bombing range.** The name is explanatory, the range is to be used for studying the pattern of multiple or cluster drops and skip bombing. Water and land area will be included in this range.

These are the three major buildings presently nearing completion at AFAC:

• **Armament engineering building,** a three story fireproof and air-conditioned building. Engineering testing, instrumentation development, design and modification will be carried out at this unit.

• **Heavy systems building,** a two-story layout, will handle the items too big or heavy for the armament engineering building, and on its second floor will house the centralized flight and range data processing equipment and flight operations communication center.

• **Armament installations building** is a workshop for installing weapons in all kinds of aircraft. Basically, the layout is that of a hangar more than 300 ft square. This kind of a building is dictated by the stringent requirements for installation of bombing systems now under development. Those requirements say that the airplane must not move more than one degree of arc about any axis during the installation of the bombing system.

▶ **Armament Lab**—The complex instrumentation at AFAC originates in the Armament Test Facilities Laboratory.

"We're working toward an instrumentation setup that will let us follow the progress of a flight test during the test. We can avoid a lot of data reduction that way," said Lt. Col. Gilbert Foster, Chief of the lab.

Instrumentation can be developed or designed at the lab, it may be procured from other ARDC centers or other defense agencies. But over three-quarters of the supply comes from contracts with industry.

The general policy calls for the lab to produce its own items with in-shop capability only when industry—through lack of available instruments or reluctance to produce a small quantity—is not able to do the job.

Guidance for the lab comes from the Deputy for Plans, and there is coordination between the lab and the test support and test operations groups.

▶ **Problems**—"You can get some idea of the complexity and accuracy of the instruments we have to develop," said Foster, "when you consider the desired accuracy of the systems we have to test. Instrumentation accuracy has to be one order of magnitude greater than that of the test system."

"We depend heavily on photo-optical data now because it's more accurate than modifications of electronic devices that were originally designed for other purposes," he added. "But photo-optics systems are going to be superseded because of the man-hours necessary for data reduction."

"We need a system that will give us trajectories," put in Robert C. Hoffman, ex-Navy submarine commander now heading the Office of Plans and Control in the lab. "In this business, you have to know about the misses as well as the hits, path data will give you that kind of information.

"Then there's a problem in evaluating airborne fire-control systems. We've got to have the relative distance and time orientation of the aircraft involved at extreme speeds and altitudes," he emphasized.

▶ **Time Standard**—Hoffman explained the timing system which provides the common datum line for all instrumentation on all ranges. A time code, calibrated by Station WWB in Washington and with a minimum time interval of 0.1 millisecond, is broadcast from the base.

Each range has its own rate selector

which is used to control or actuate the instruments

The basic time accuracy is 0.0000001 second

Hoffman expected that within three years the Center would have available a central computing station to present reduced data concurrent with sensing it. Although an expensive item, Hoffman said that such a station would probably pay for itself several times over in the first year's operation

Heart of the station will be an electronic digital computer. Instant control of a test run will be simplified by a variety of graphic presentations of the data

▶ **Typical Tests**—The special instrumentation which gathers data during test runs is largely optical. Development of this equipment is one of the functions of the Photo-optics Branch of the Laboratory

"On a typical level bomb run," said Andrew C. Cobb, Chief of the branch, "we use photo theodolite tracking for position of the aircraft. Inside the plane there is a camera fixed to the gimbals of the bombing system being tested. As the plane comes in for the run, pictures are taken of the photogrammetric range to determine the attitude of the plane. The pattern of the bomb drop we can get by seismic instrumentation or by photography."

Cobb explained that a typical dive bombing run required clearing out a line which might extend for 50,000 yd as an upper limit. At the target center is a camera array, and along the flight line is a series of cameras placed so that their line of sight is about at 90 degrees to the plane's line of flight path. No bombs are dropped in such a test.

"Data reduction from photographs

Col. A. W. Cruikshank, Jr
Chief of Staff

■ EGLIN

takes weeks,' Cobb said

▶ Camera Methods—Pictures of dive and level bombing runs used to be taken with four K-24 aerial cameras mounted in tandem. But flight speeds got too high for the 10 frame-per-second speed of the K-24 and the center has switched to 35 mm. Flight Research synchronous cameras which will handle up to 40 frames per second.

The lab has under development two cameras that can be operated by a remote radio link, and will use these in bombing tests as soon as they are available.

Aircraft attitude, obtained from pictures of known patterns on the photogrammetric range, is found after a seven-hour computation per picture to determine angles and distance.

As a result of this tedious analytical method, the lab has gone to a vertical photogrammetric rectifier, which is a mechanical-optical projector. The projector can be rotated until the picture corresponds with a master plan of the ground pattern, then the angle of the sightline can be read directly.

Current estimates make the processing time per picture only 30 to 40 minutes instead of seven hours.

▶ Vision Aids—As might be expected, weather and altitude combine to make tracking of dive bomb runs quite difficult. Even though the plane starts down a 10-deg. conical corridor, that's a lot of sky at 40,000 ft.

The lab has under study the feasibility of using a visible light or infrared seeker to locate the aircraft so that the cameras can be zeroed in. It would also aid the phototheodolites and eliminate some of the effects of haze on that equipment.

New Contraves cine-phototheodolites, ordered two years ago from the Swiss subsidiary of Oerlikon, are now being delivered to AFAC. These will be set up on the range for pattern and skip-bombing. Automatic computation circuits will give corrected true azimuth angles and corrected angles of elevation and azimuth. Ancillary equipment for reading the Contraves film record is under development by a contractor in the United States.

▶ In-Shop Development—Cobb said that the collimation device was an example of the in-shop capability of the lab. A collimator gives parallel light beams with a reticle superimposed, and is used for providing a fixed reference for photographic data methods.

He cited the case of fixed gunnery camera data where the camera moves because of the impact loads during firing. But the collimator provides a fixed set of crosshairs unaffected by camera jump and permits much easier assessment of the armament system.

These are some of the ground instruments developed by the Photo Optics Branch. But evaluating air-to-air weapons is an entirely different problem. There the problem is to measure, from one moving object, the path of a second moving object fired from a third moving object possibly at a fourth moving object.

▶ Targets and Misses—Back in the earlier days, a pilot went up, fired at a sleeve target and and came down to count the holes. This was a fine system for his pair of .30-cal. machine guns, it leaves something to be desired now that he shoots projectiles that can destroy the entire target with a single hit.

The technicians at AFAC figured that one good way to evaluate airborne systems and not clobber too many expensive targets would be offset the sight by a known amount and then shoot. If you could record the misses and compare them with what they should have been due to the offset, you could get a reading on the sight system effectiveness.

This is done with one or more of several devices known as Firing Error Indicators. Carried aloft in tow targets, these FEIs work by electronic or acoustical means to collect or transmit data on the projectiles that miss the target.

EGLIN

New systems with the ability to measure a 50-ft miss by a 50-cal bullet will be coming along shortly.

▶ **Red Birds**—There has been one problem in the use of towed targets for firing tests. The targets often disintegrate before they are shot at. This was discouraging, and so the Electromechanical Branch of the lab was asked to look into the situation.

The Center had been using the A-1 target, a Vee-tailed midwing monoplane with a Vee-shaped towing arm. These could be towed at Mach 0.6 above 30,000 ft only on rare occasions; more often they came apart. A modification program produced no great improvement.

The basic faults were instabilities resulting in oscillations. After a series of tests to isolate some of these and to observe them, the engineers in the EM Branch developed a mockup of a redesign which they thought would do the required job.

What they did was to take the standard target, and sweep its wings back at a 45-deg. angle, by cutting out a wedge at the trailing edge and making a fairing for the leading edge. Then they chopped off one of the Vee tails and rotated the other on the fuselage to a vertical position. The result was the Red Bird, a trim modern looking tow target.

After three flight tests, the Branch got the go-ahead to produce a few experimental versions. The targets have performed up to the limits of Mach 0.82 and 42,000 ft., imposed by the particular type of Republic F-84 Thunderjet used for tow planes.

A production contract for the new Red Bird has been let to East Coast Aeronautics.

▶ **Instrument Men**—The technicians

Lt. Col. C. J. Kronaner
Director, Test Operations

■ EGLIN

who install, operate and maintain the range and aircraft instrumentation used at AFAC are in the branches of the Technical Support Directorate headed by Maj Louis Schaffer

Directly responsible to the commanding general, Maj Schaffer has under his jurisdiction the instrumentation data programing and technical services

Schaffer said that the instruments that have to be installed are often bulkier than the installation to be tested, and more numerous than those needed to determine aircraft performance While he talked, he pointed out on two charts of typical installations in a North American F 86, the kinds of specialized instruments

"One of the things that worries an armament man is gun gas", said Schaffer "You can ruin an airplane with a single explosion of accumulated gases So we have to sample the gases in the gun bay of a fighter during the firing tests To do that we need these sampling bottles and collector tubes

"Another item is the camera installation in the modified drop tanks and inside the duct They're there to photograph flames," he said

"When you have a gun layout like the Sabre, with muzzles close to the air inlets, you have flames playing around where the air is supposed to go in The designers want to know if the flames enter the intake

Project Officers—The men who head the investigating teams during tests are project officers from the Test Operation Directorate under Lt Col Clifford J Kronauer

They get their test directives through Col Bechtel's office, and the project engineer sets up the test plan Where the officer is a pilot, he is encouraged to fly the missions himself

When the data comes back, the project officer has it analyzed, writes the report, draws conclusions and makes recommendations

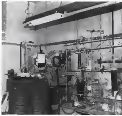
In contractor-support tests, the project officer is merely a liaison man His job is to see that the support given is sufficient.

Kronauer's organization is a functional one, broken into five branches Fire control, bombing, weapons and missiles, biological warfare-chemical warfare, and aero-ballistics The last group has yet to be activated

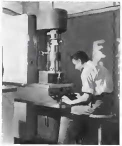
In addition, there is an Office of Analysis and Reports set up as a pool of consultants for extremely difficult problems Now composed of four people, and aiming toward a total of 10, this group can supply men with a large amount of formal training in mathematics and physics plus a great deal of test experience

WARHEAD INSTRUMENTATION of Aerobee sounding rocket returns data for atmospheric physics studies.

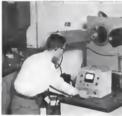
CLOUD CHAMBER, research tool in cloud physics section, simulates conditions from surface to 15,000 ft altitude



OXYGEN ABSORPTION SPECTRUM is studied in this laboratory. Gas-filling systems (foreground) control pressure in absorption cell.



ELECTRON MICROSCOPE gives cloud nuclei data. Photos enlarge particle diameters 75,000 times.



VACUUM MONOCHROMATOR is used to check ultra-violet spectrum of hydrogen. Ionization gage (foreground) shows vacuum in chamber.

Cambridge's Bailiwick: Earth, Sky, Sea

AFCRC's three directorates study geophysics, atomic warfare, electronics; research center also administers Project Lincoln.

By Irving Stone

Boston, Mass.—One of the big factors contributing to progress in general scientific research is the Air Force Cambridge Research Center (AFCRC), Cambridge, Mass.—one of the nine major centers of the Air Research and Development Command (ARDC).

AFCRC's mission is to accomplish research, development and tests in three vital fields, each the responsibility of a directorate:

- **Geophysics.** This activity encompasses work in terrestrial sciences, upper air research, atmospheric devices, atmospheric physics, atmospheric analysis, and ionospheric considerations.
- **Atomic warfare.** This work encompasses factors of radiobiology, radiochemistry and nuclear physics. Included in this activity is a field experimental branch and a physical instrumentation laboratory.
- **Electronics.** Included in this activity is the study of communications, RF components, antennas, propagation factors, and computers. Work of this directorate is described elsewhere in this issue.

▶ **Other Groups**—In addition to these three research divisions, AFCRC is charged with the administration of Project Lincoln (an air defense study), and its necessary air support, including that required for systems wide testing. This project is centered at Lincoln Laboratory, operated by Massachusetts Institute of Technology (MIT), under contract with the Air Force.

AFCRC also has established the 6520th Test Support Wing at Hanscom AFB, Bedford, Mass., with two flight squadrons and an aircraft control and warning squadron to provide specialized support to Project Lincoln and the three research directorates. Eventually, all AFCRC activities will be centered at Bedford.

History

When it became apparent, after World War II, that the Office of Scientific Research and Development (OSRD) would not continue to operate its contracts on a civilian basis at Cambridge, the military felt that some of these projects should be carried on.

Two of the activities doing electronics research for the (then) Army Air Force under OSRD were MIT's Radiation Laboratory and Harvard's Radio Research Laboratory. Military personnel started interviewing people in these organizations in August 1945. The staffs of these laboratories included some of the country's most capable men in their specialized fields.

▶ **First Station**—In September 1945, the Air Technical Service Command (now Air Materiel Command) established the Cambridge Field Station under the supervision of Watson Laboratories, Red Bank, N. J.

In April 1946, a research division (radio physics) was established at the station. In October 1946, J. W. Marchetti, who previously was the commanding officer at the station, was designated acting chief of the Research Division.

Geophysical research was transferred from Watson Laboratories to the station in November 1948. Initially, headquarters for this new addition were set up at Watertown, Mass., but were later removed to Summer St., Boston. (Additional geophysics facilities are located in Roxbury, Mass. and Boston.)

▶ **Name Change**—In July 1949, the name of the station was changed to the Air Force Cambridge Research Laboratories. In June 1951, it became the Air Force Cambridge Research Center under the command of ARDC.

In August 1951, Maj. Gen. J. F. Phillips took command of AFCRC, with Marchetti as his technical deputy (top civilian). Dr. Edwin G. Schneider became director of electronics research, and Dr. H. E. Landsberg was made director of geophysics research.

Appointment of these civilians to chief posts meant that the center was fundamentally established as a scientific organization, as distinguished from a purely military setup. These civilians still hold their top positions. The commanding officer now is Maj. Gen. R. C. Maude.

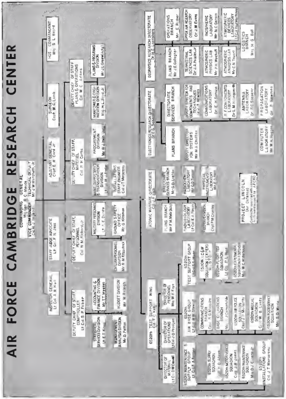
▶ **Atomic Division**—The Atomic Warfare Division was set up in October 1951 under Col. J. C. Jack, at Hanscom AFB. He still heads this activity.

Early in 1951, the Command started planning for the construction of permanent laboratory buildings for all three directorates, plus an airbase facility, at Hanscom Field, Bedford, Mass. Early last year, the premises were leased from the state.

Meanwhile, the 6520th Air Base Group was established at the field. This organization became the 6520th Test Support Wing in the spring of 1952, for the function of providing flight tests and other support for AFCRC and also for Project Lincoln.

Work in the Atomic Warfare Directorate so far has been concerned largely

Maj. Gen. Raymond Coleman Maude, commander Cambridge Research Center . . . communications expert . . . born Framingham, Mass., 1902 . . . graduated U. S. Military Academy and commissioned in Signal Corps 1926 . . . served with signal troops attached to infantry and cavalry unit . . . got into aircraft warning work 1940 . . . in 1941 was chief of the Signal Corps aircraft warning division . . . communications officer 9th Bomber Command and 29th Tactical Air Command in Europe, World War II . . . asst. dir. of requirements for deputy USAF chief of staff for development . . . commanded 1009th Special Weapons Squadron . . . director of communications in the office of deputy USAF chief of staff for operations . . . took command of Cambridge March 1953.



with planning and organization phases Only a small part of the manpower now alloted to this function has been specifically authorized for it—the bulk of the authorization has been withdrawn from the other research directorates

▶ **Project Lincoln**—Work being done in Project Lincoln—basically a research and development program—is a broad study of air defense designed to improve the capabilities of the Air Force, Army and Navy in parrying an atomic air attack on the U S The investigation is slanted to permit these three branches to accomplish a better air defense. The work encompasses a multitude of activities and is in no way limited in scope

MIT's effort at Lincoln Lab is conducted on a tripartite arrangement, with the Army, Navy and the Air Force contributing in the furtherance of the Lab's objectives The contract for Project Lincoln is between the Air Force and MIT

The Project actually is not a part of the AFCRC organization, which is charged only with rendering to it administrative and logistical support. Nevertheless, its impact on the administrative and support (manpower, facilities, aircraft, and other services) programs of the Center is at least the equivalent of the impact of the three component research directorates combined

Almost all of the support manpower authorization of the Center in the past 21 months has been furnished specifically because of Project Lincoln. Additional manpower will have to be furnished before the full requirements in support of Project Lincoln are satisfied

Activities of the Electronics Directorate are covered elsewhere in this issue

Geophysics Research

Some of the highlights of activities in the Geophysics Directorate, covering the functions, projects and aims of this activity, are related here

Basically, the geophysics activity functions to study the medium in which any kind of aircraft—manned or unmanned—will operate Only about one third of the work done by the Geophysics Directorate is handled by its own personnel Two thirds of the organization's annual expenditures are funneled into private organizations for study

About 93% of GRD's efforts is directed in studying the atmosphere from the ground up to such heights that can be reached directly or indirectly The other 7% of the studies is concerned with special projects On these, GRD is just picking up the ball because there is some specific AF interest in these phases, which basically are being conducted by other defense agencies

■ CAMBRIDGE

▶ **Broad Scope**—The scope of GRD's work is extensive Each year higher altitudes are reached in flights of all types of vehicles With each new height reached, new phenomena appear.

In low level flight, the most important problems include fog, thunderstorms, rain and icing

In the 30,000 to 100,000 ft altitude range—the region of today's and tomorrow's jet flights—turbulence and high winds are important considerations

Above 100,000 ft, atmospheric composition becomes important Here, problems stem from the existence of ozone and other gases, solar radiation, aircraft skin temperature considerations, irregular ionozation difficulties which put limitations on radio wave propagation, and other suspected factors which could affect flights

▶ **Looking Up**—To ferret out some of the answers, the searchlight technique is used for scanning atmospheric densities up to about 50 mi Above this altitude observations are made of meteorite trails—bringing the observation up to about 90 100 mi Both of these are indirect methods

For direct observations, about every three weeks an instrumented sounding rocket (Aerobee) is pushed up to about 70-80 mi Results are used to calibrate indirect methods

Data obtained are digested and forecasts are made for requirements which may exist now or in the foreseeable future.

▶ **Publications**—To insure that research results get the widest possible dissemination—first, among Air Force components and the other branches of the Armed Services to whom such information is pertinent, and then to scientists of other government agencies, universities and research institutions—GRD issues or sponsors a number of publications

A single type of publication could not answer the many requirements for which the research results of the laboratories and the nearly 150 university contracts are intended Accordingly, GRD tailors these reports to fit the needs of the Air Force in the field, the design and instrumentation people, or the laboratory scientists who desire certain data on which to base further research.

Atmospheric Physics

The Atmospheric Physics Laboratory is headed by Peter H. Wyckoff The function of this activity is to study the composition and physical structure of the earth's atmosphere. This is done by measurements on the ground, in aircraft, in balloons and in rockets The field of work is broken down into five classes

▶ **Cloud Physics**—In this activity, interest is in the physics behind the formation of clouds, how they grow, how rain forms and falls, and the general theory behind cloud seeding, for the opening of holes in cloud decks for visibility Another consideration of this laboratory is the suppression of ice fogs in the Arctic, as well as ordinary water fogs.

These atmospheric physics studies are attacked in two ways

• **First, in the laboratory**, where certain fundamental experiments are conducted to find out how water droplets form from nuclei (dust, sea salt, sulphuric acid droplets in industrial areas) in the atmosphere

• **Secondly, in the field**, where the basic information is taken for correlation An aircraft is flown into the clouds, and measurements are made of all cloud parameters—droplet size, liquid content, temperature structure, and the number of nuclei in the air mass surrounding the cloud This procedure is a check on the theoretical understanding of the process in the cloud Certain critical experiments, such as actually seeding the cloud on a small scale, are conducted to see if it can be made to behave the same way as in the laboratory

In addition to the aircraft studies, there is a cloud radar group which investigates clouds by means of microwave radar The wavelength employed is very sensitive to clouds

▶ **Visibility**—The problem of visibility is primarily one of seeing in the atmosphere, from the viewpoint of air-to ground, air-to-air and ground-to-air

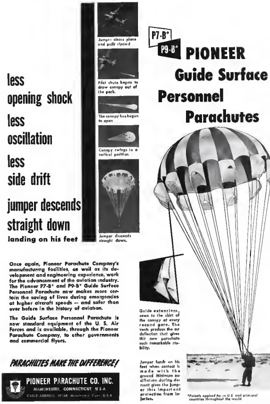
The physical problem of detection depends on contrast of the "target" against the background For this reason, the atmospheric physics lab studies the brightness of the sky, illumination of the target, and the scattered light between observer and target

Sky brightness is studied especially around the sun Measurements are made from the ground and from instruments carried aloft by balloons, some of which go to 100,000 ft

Illumination of the target is presently measured on the ground, especially during twilight and night The illumination at night, when the moon is above the horizon, has been studied to determine the minimum conditions of target detection

Scattering of light in the atmosphere is due to air molecules and dust particles The theoretical study of the scattering of dust particles is only partially understood Accordingly, an extensive thoretical program is under way

Since these dust particles are very numerous up to 30,000 ft., the number and sizes of the particles are measured



from aircraft. The technique employed uses what is known as an impactor. This is a film strip coated with an oily substance over which a measured volume of air is directed during flight. The dust particles stick to the film and the size and number are examined under a microscope. From the experimental results, the amount of scattered light can be computed, using theoretical data as a base reference.

The practical importance of the scattered light study is the determination of the effect of reduced visual range in dusty atmosphere as compared to a dust-free atmosphere.

As part of the visibility program, experiments have been carried out with a searchlight technique to measure atmospheric density and temperature up to 250,000 ft. altitude. In this work a searchlight beam is modulated by a rotating, venetian-blind type shutter.

At a distance of about 10 mi. from this first searchlight, a second light is installed, in which the light source has been replaced by a photo-sensitive receiver. This second searchlight scans the beam of the first searchlight and measures the light scattered by the original beam. The scattering is proportional to the atmospheric density. The modulation is used to reduce the noise level caused by light sources of the surrounding area, as well as the permanent emission of light occurring in the higher layers of the atmosphere.

From the density data obtained, the temperature profile in the atmosphere can be computed. Thus it has been determined by these experiments that the temperature is about −60C at 40,000 ft. At about 160,000 ft. the temperature has been determined to be 10-20C.

▶ Atmospheric Composition—On the earth's surface and up to about 60 km. (37½ mi.), the composition of the atmosphere is pretty much constant with respect to percentage of gases, except for variation in pressure and temperature conditions. Above the 37½-mi. altitude, changes in composition occur.

One reason is because of diffusive separation, where the lighter gases rise and the heavier gases settle (Signal Corps project).

Another reason is the effect of ultraviolet rays on the gases in the higher upper atmosphere above 37½ mi. (This condition is the basis for a large portion of CRD's composition work.)

The ultra-violet rays from the sun produce chemical changes in the gases of the upper air and cause formation of new compounds which do not exist in any appreciable quantity at ground level. Some of these gases are ozone, nitric and nitrous oxide. They shield

the lower atmosphere from any ultra violet wave lengths shorter than 2,900 Angstrom units.

The effect of the ultra violet rays on the gases is resolved both in the laboratory and by means of rockets.

• **In the rocket study,** the Aerobee is the primary missile used.

• **In the laboratory,** mixtures of atmospheric gases are made at the pressures comparable to that which would normally be found above 37½ mi. These gas samples are exposed to ultra-violet radiation in the region from 1,000 to 2,000 Angstroms. This is done in a partial vacuum to duplicate upper atmospheric conditions. After ultra violet radiation exposure, the gases are analyzed and the new products formed are determined.

Knowing the intensity and wave length of the ultra violet in the high upper atmosphere, the concentrations of the products which should exist at about 37½ mi. can then be predicted. (The reason for lack of conclusive existence is that rocket time at altitude is very short and conclusive data is very difficult to obtain.)

This study of composition change is important because it determines the temperature structure of the upper air and will have considerable bearing on "future" high altitude flight of manned aircraft, since some of these gases are corrosive to aircraft materials, could be harmful to breathing by humans (under conditions for possible conservation of oxygen carried), and could affect engine performance if supercharging methods were used.

To determine the amount of ultraviolet present in the high upper atmosphere, rockets with small spectrographs are flown to altitudes of 37½ mi. or higher and spectral distribution of these radiations are obtained as a function of altitude.

▶ **Atmospheric Electricity**—Earth-air electric currents are another phase of work in the atmospheric physics laboratory. The earth and the ionosphere surrounding it may be considered electrically as a huge spherical condenser. There is a constant flow of approximately 1,800 amp. between the ionosphere and the earth. This current flows through the atmosphere and is carried by ions which exist in the atmosphere due to cosmic radiation and natural radioactive materials.

The source of this charging current is believed to be the thunderstorm, of which there are several hundred in existence throughout the world at any moment.

Laboratory personnel are studying the distribution of these air-earth currents and are attempting to explain how they arise and how they distribute themselves throughout the earth's surface.

Here again, this work is done in the laboratory and in the field.

• **In the laboratory,** distribution of ions present at the earth's surface is studied, and how the ions behave under the influence of the earth's electrostatic field. Through this approach, familiarity is gained with the size range of the ions and the charges they carry. Cosmic ray intensities are correlated with the generation of these ions in the atmosphere, from this stems the prediction of the number of ions that will be present at any particular altitude and latitude.

• **In the field** (6520th Test Support Wing), there are a number of aircraft instrumented for measuring the conductivity of the atmosphere, the earth's electrostatic field gradient and the intensity of the air-earth current at all aircraft altitudes. Conductivity and field strength equipment is also sent aloft in large plastic balloons up to 100,000 ft.

This work has been important to the meteorologist because it has established an extremely sensitive method that may be used for detecting turbulence and mixing.

It has been learned, for example, that the boundary layer of atmosphere near

the surface of the earth (called the exchange layer) can be detected with ease and accuracy using conductivity methods, and normally is found at an altitude of between 4,000-6,000 ft

It was formerly believed that high mountain peaks extended above this exchange layer, but recent conductivity tests have shown that this layer is warped by the mountains and covers them completely The boundary layer governs the energy exchange between the air and the ground and is important in forecasting weather at the surface

The atmospheric conductivity method is also extremely sensitive to radioactive contaminants in the atmosphere and is used to trace the distribution of radioactive waste products from any ground-based nuclear source

Also, as a result of work in atmospheric electricity, it has been possible to develop a method for discharging aircraft in flight and reducing this charge to essentially zero The charge is led from the aircraft surface to a static discharger in the tail This equipment is heavy and experimental, but indicates possibilities for practical aircraft application in suitable size and weight

▶ **Rocketsonde Group**—The sounding-rocket activity is primarily interested in the temperature density structure of the atmosphere up to rocket altitudes of about 85 mi Measurements are made by means of spark gap modulators, shock wave effect on the missile, and by alphatron (radioactive) gages

In addition, measurements are also being made of meteor trails to determine the wind structure of the high upper atmosphere in regions not accessible to rocket flight This is a supplementary study continuing where rockets leave off

The rocketsonde group is also interested in studying the ionosphere, and sends rockets into the lower ionosphere to obtain recordings of ion density as a function of altitude This work is directly related to design criteria for guided missiles, since knowledge of the density structure is necessary to design control surfaces Ionospheric densities are necessary also to determine the possibility of radio guidance systems for such a missile

This phase is all field work—actually done at Holloman AFB Equipment is built at GRD and at various universities and institutions under contract

Ionospheric Physics

Head of the Ionospheric Physics activity is N C Gerson Most of the laboratory's work is concerned with the atmosphere above 50 km (about 32 mi) and may extend to 15,000 km

■ CAMBRIDGE

(about 9,500 mi)—right to the end of the exosphere

The ionospheric region is important for various reasons

• From 50 km up, there are ionic layers which make possible long distance radio communications

• From 50 to 1,000 km (about 625 mi) there are the auroral effects. This phenomenon is important for radio communication work, particularly in the arctic; and secondly because of its relationship to activity of a geomagnetic nature

• A third reason for ionospheric study is that the region from 50 km up is considered to be the operating medium of the "future" Air Force

There is also the possibility of extracting energy from the high atmosphere. For example, it might be possible to send a missile (air worm) up into the outer reaches and have it extract energy from all the charged or dissociated particles it encounters, either for storing this energy or to make the missile ascend higher

▶ **Radio Factors**—One of the studies which the Ionospheric Physics Laboratory has made was done in cooperation with radio amateurs over both North and South America, including the Caribbean Islands. The hams reported to the laboratory whenever they encountered certain types of special radio conditions. This permitted laboratory scientists to determine the existence and location of an abnormal condition of the ionosphere—known as sporadic E (E_s)

It has been determined that with E_s occurrence the range of radio communication can be increased appreciably—in effect, new channels of radio communication are opened up. By the movement of these E_s areas, the existence of winds can be determined near the 100-km. (about 60 mi) level and up. This helps in the study of the global circulation patterns

The E_s formations affect communications in the 20 to 300-mc band. These E_s clouds are those with either high electron concentration or concentrated turbulence, and one of them can cover an area half the size of the U. S. They occur mainly during the summer months

▶ **Aurora Effects**—The aurora permits study of radio blackouts in the arctic. One of the Geophysics Research Directorate's jobs is to predict the occurrence of the aurora

For long-distance communications, reflections come from the ionospheric F_2 layer at about 300 km (about 190 mi). The aurora comes down to a level of about 60 mi, so that when this phenomenon is present, it intercepts the radio waves (8-15 mc/sec) between the transmitter and receiver and the radio waves are lost through scattering and absorption

However, when a frequency of 50 mc/sec (VHF) is used, then the auroral screen can be used as a reflecting screen and it becomes possible to communicate with stations which could not be contacted before

The real benefit of using the auroral phenomeon is to permit the use of lightweight, long-distance, high-frequency sets for communication

The spectra of the aurora are being studied also. This gives an indication of the constituents of the high atmosphere. The study is important in amassing a general background picture of the atmosphere—its extent, and the particles and streams coming into it. It also aids in the prediction of formation and types of aurora

Terrestrial Sciences

Dr James Peoples heads this GRD research phase. This group studies the interaction of the atmosphere and the earth's crust. It also investigates the earth itself, and the oceans and ice. All of this work is for aircraft support and guidance. For a good part of the work, reliance is placed on seismology

▶ **Sonic Tools**—One project is concerned with the determination of stra-

tospheric winds and temperatures by sonic measurements. TNT charges are set up on the earth and sound waves reflected from the temperature inversion levels in the atmosphere up to 80 km (50 mi.) are noted. By observing the travel time and azimuth of the reflected waves, the wind effects at these altitudes can be determined, as well as the temperatures that cause these reflecting layers.

This atmospheric acoustics method is not as direct as balloon observation, but it eliminates the toting of instruments to altitude, and the technique can be performed at any location and at all seasons—at times when balloons would not be employed. Also, height can be reached that cannot be attained by balloons.

Advantages over rocket flight are that the latter method is done infrequently and is expensive.

In actual practice a site is chosen and rung for about a 200-mi. radius from the shot point with a series of recording stations.

The technique was developed at GRD, whose field parties participate in the work along with personnel from the University of Denver and the University of Alaska, under contract.

►**For Tomorrow**—This particular research is not directly applicable to everyday flight, but it will fit the future flight picture for both planes and guided missiles. Primarily the work is done to gather data for establishing a scientific background of the general physics of the atmosphere—how winds and temperature vary with the seasons.

The project has been under way for about six years and is just about complete. It indicates that the atmospheric acoustics method is scientifically valid. Results have agreed very closely with the National Advisory Committee for Aeronautics' altitude temperature curve. The work has also verified the assumed portion of the NACA data.

►**Pack Ice Study**—Another project of the laboratory is the investigation of arctic pack (permanent) ice north of Alaska, to determine thickness, structure and breakup characteristics.

Landings were made with ski-equipped aircraft for setting up seismometers and surface charges to determine relationship of salt water ice thickness to air-coupled shock wave transmission. From the reflected wave analysis, ice thickness could be determined as well as presence of ice faults and ocean depths.

Data tell whether the ice is sufficiently strong to support landing aircraft and whether it will stay intact or break up—important information for establishment of a camp, rescue or operating

air base and weather stations.

To extend this type of survey to all the ice over which flight could be made, the laboratory has developed a radio seismometer which can be dropped by parachute so that it will telemeter data back to the plane when a 100-lb. bomb is dropped on the ice in the general area of the seismometer. A recorder in the aircraft pen-charts the shock wave characteristics. Analysis of the data provides ice thickness, ice faults and ocean depths.

► **Other Projects**—Other studies of the laboratory include investigation of microseisms—minute earthquakes on the earth's crust caused by atmospheric fluctuations.

To aid in landing operations on unimproved fields, the laboratory is conducting soil-bearing studies (trafficability).

To promote navigation knowledge, the laboratory is investigating geomagnetic fields.

Interest is already projected in the solar eclipse due in 1954. This should provide data for mapping the earth's surfaces and promoting navigation and guidance.

A project concerned with a floating ice island in the arctic is under study to determine feasibility of base establishment. This work is described in another article in this issue.

Atmospheric Anolysis

Head of the atmospheric analysis activity—a weather forecasting group—is C. N. Touart.

This coordinated and directed effort for the solution of weather forecast problems has never before been available on such a scale in the history of meteorology.

The feeling is that the art of forecasting has been leveled off on a plateau while knowledge is gathered for a move up to a higher plateau of understanding weather phenomena.

► **Numerical Prediction**—One of the present considerations of the atmospheric analysis lab is the operational testing of the numerical prediction technique that is based on the numerical solution of the fundamental laws of motion. These are the laws which govern the motion of all material bodies.

The ability of meteorologists to modify and specialize these laws so they can be applied to the atmosphere has only come about in the last 10 years. This achievement makes meteorology a branch of the physical sciences and the laboratory capitalizes on all the data generated by the various phases of these sciences instead of starting from scratch.

► **Balloons Help**—For its numerical prediction technique, the laboratory uses data obtained by balloons released all over the country on a routine basis by the U. S. Weather Bureau, Air Weather Service and the U. S. Navy. These are equipped with radio transmitters and send back reports of temperature, wind and pressure conditions in the upper atmosphere. These balloons may range to altitudes between 10 and 15 mi.

The data collected are fed to GRD, where the computing machines go to work and return a forecast for 24 or 36 hr. in advance. The computer can accomplish this because it has been instructed to take into account more details than the human forecaster can concerning the state of the atmosphere.

At present, it is fairly clear that the computer can significantly improve on the performance of the field forecaster in predicting the field of motion in the atmosphere. It can forecast unexpected developments—birth of new storms, irregular motions, and sudden changes of weather.

► **Long-Range Forecasting**—The laboratory aims to extend the time-range of weather forecasts. The objective is to forecast accurately by from three days to one month.

Long-range forecasting reduces the limits of accuracy with which a forecast is phrased, both with respect to space and time. It is in a much more primitive stage than short-range forecasting, and the problem is "how accurate is it at the moment?" This question is what the development and evaluation group at the laboratory is trying to answer.

For the past five years the lab's personnel have been studying the general circulation of the atmosphere—the gross feature of its motion. Forecasting this general circulation is the key to the long-range forecast, according to many meteorologists.

Atmospheric Devices

The atmospheric devices activity is headed by Lt. Col. Paul Worthman.

The function of this group is to develop balloon systems, including the carrier and its instrumentation. The instrumentation covers both ground and airborne equipment for recording temperature, pressure and turbulence up to 100,000 ft. The laboratory is also charged with test-proving of large and small instruments which are developed, before acceptance by the Air Force for production.

One of the laboratory's big projects, known as Moby Dick, uses large plastic balloons to carry research instrumentation to altitudes between 50,000 and 100,000 ft. for the investigation of wind fields.

Directorate Probes Air and Weather

Cambridge—Complex geophysical problems are being resolved here in a concentrated research, development and test program aimed at simplifying operational difficulties of present and future aircraft

This work, being conducted by the Air Research and Development Command's Air Force Cambridge Research Center (AFCRC), Cambridge, Mass., is being pushed by the Geophysics Research Directorate (GRD), one of the center's three research divisions

GRD's overall study embraces both laboratory and field investigations. Its laboratory phases, together with some of the numerous studies under way, are outlined elsewhere in this issue. Some examples highlighting the many field projects—aimed to unravel threads of geophysical phenomena—are related here.

Mountain Wave

GRD's Atmospheric Analysis Laboratory is conducting a study known as the Mountain Wave Project, with field work under the direction of Dr J. P. Kuettner The project contract was signed in the fall of 1950, and is still continuing

The broad aim of the study is to explore airflow over mountains, and its implications to aviation The Sierra Nevada mountain range area was selected for the field experiments, because previously glider pilots had used the mountain wave in this region to climb to over 35,000 ft, which indicated that the wave was more pronounced in this area than over other mountain locales in the U S

In addition to GRD personnel, the entire project has involved the University of California personnel under the direction of Prof Holmboe, Meteorological Department Head, the Naval Ordnance Test Station, Inyokern, Calif the Air Weather Service, U S. Weather Bureau, Southern California Soaring Assn; and other participants

▶ **Basis of Study**—Airflow over a mountain range forms a system of waves downwind of the mountain. It is this phenomenon which is the basis of the project study Both gliders and powered planes have been used in the study to take advantage of the ascending part of the wave to gain altitude.

In the project, the powered Convair BT-13 has been used for flights close to the ground (where glider operation would not be feasible) and up to altitudes of 18,000 ft Pratt Read gliders used have been taken to considerably higher altitudes, limited only by the lack of a pressurized cabin in the sailplane

Field phases have involved determination of the magnitude of updrafts and downdrafts and their positions with respect to the mountain Pressure disturbances have also been investigated, since these are responsible for altimeter errors Another phase of study is turbulence phenomena, especially high-level turbulence under jetstream conditions During trial flights a glider pilot has been lifted into a jetstream

▶ **Record Set**—During the project, a world altitude record for gliders was set —44,500 ft—in one of the Pratt Read sailplanes This flight had to be discontinued at this altitude because there was no cabin pressurization, although the air was still rising at 1,000 fpm

The instrumented and calibrated gliders have been tracked by cinetheodolites, radar and Raydist Radiosonde and meteorological stations were set up in the Sierra Nevada and adjacent areas to record atmospheric conditions during wave situations

A number of accidents have been attributed to the hazardous conditions produced by the mountain wave From the data that have been collected in this project there are indications that new safety altitudes would appear advisable.

Excessive turbulence and altimeter error over mountain regions are other aspects in which the Air Force is interested. The project is expected to determine the magnitude of these altimeter errors and give a better understanding of the phenomena of high level turbulence

Ice Island

A massive floating ice island, known as T 3, in the Arctic waters, is the scene of another special project in which GRD's Terrestrial Sciences Laboratory is participating Huge ice masses such as this offer interesting possibilities for Air Force use

Large ice islands were first discovered in northern waters in 1947 during weather reconnaissance flights from the Alaskan Air Command In 1951, T-3 ice island was located, when it was in a position to be occupied for camp purposes Its area was 45 sq mi

In March 1952, the first aircraft landing was made In the subsequent landing a GRD scientist was put down on the island and then others from GRD followed On this floating weather station, the GRD personnel will remain until October of this year. Other service representatives on the site include weather observers of the Alaskan Air Command, representatives of the Aero Medical Laboratory, and communications personnel

▶ **Island Under Study**—Studies are being made to determine the character of the island—why it is there, how it was formed, its thickness, structure, and breakup and drift characteristics Already, the main cause of movement has been found to be the wind, with ocean current effect being negligible

Plains Turbulence

An extensive study now being conducted by GRD's Atmospheric Analysis Laboratory is the Great Plains Turbulence Field Project This month, on the plains of Nebraska, GRD is making concentrated field observations to test certain established theories of air turbulence and heat transfer occurring between the air and the ground, between different atmospheric layers and that involved in such processes as evaporation and condensation

These trials climax four years of diversified investigations of the diffusive processes in the lower atmosphere

▶ **Results Expected**—It is expected that considerable new data will be amassed on the portion of the atmosphere nearest to the ground, and new theories should be developed About 125 scientific personnel from 12 universities, institutions and military agencies are participating in the project phase

The results of this field experiment primarily will be of military interest, but commercial, agricultural and public health activities should also benefit

During the field trials, some groups will make observations of windspeed and direction at numerous elevations up to about 5,000 ft, with cup type and cylindrical anemometers, photo-theodolites, and smoke puffs. Fluctuations and stress of the wind on the ground and at various levels will be measured by other groups

▶ **Measuring Temperatures**—Temperature profiles up to about 10,000 ft will be measured by aircraft observations and radiosonde Fluctuations of temperature up to 75 ft will be recorded by cable anchored radiosonde

Profiles and fluctuations of moisture —one of the most important constituents of the atmosphere—will be observed and evaporation rates for hourly and daily periods will be measured

Quantitative and qualitative diffusion measurements will be made to check on the rate of spread and dissipation of smoke puffs near the ground and at heights of 5,000 ft

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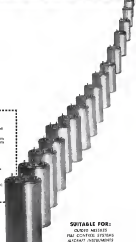

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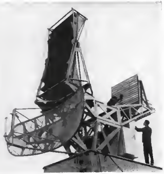


AVIONICS IN THE AIR FORCE

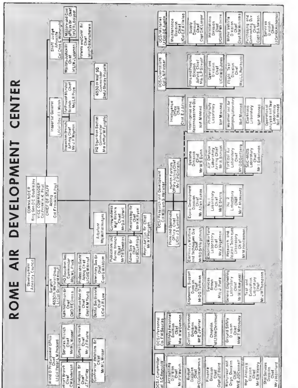
Avionics has altered the techniques of aerial warfare during the past decade and now promises to completely reshape the character, equipment and tactics of military air power during the next decade.

As a result, avionics—electricity and electronics in aviation—is one of the fastest-growing segments of the modern aviation industry. Firms well-established in aviation for decades are expanding to develop new capabilities and finding new tasks in avionics. Many new firms never before associated with aviation are becoming an important part of the industry through their technical contributions to avionics. Although the basic expansion program for the airframe, engine and accessory manufacturers for current military air power needs is reaching its peak, there is still an acute need for additional avionics resources, both in research and development and in production facilities. Already nearly half the total cost of a modern jet bomber can be accounted for by its avionics equipment.

Avionics now provides the radar eyes, the radio ears, the computer brains and the servo system muscles for individual aircraft and missiles. In addition to expanding and perfecting these roles, avionics is also destined to provide the central nervous system to knit together the many complex aerial weapons systems into the over-all super weapons system of military air power.

The Air Force's program in avionics handled through the Air Research and Development Command is the most important single force behind some of the major technological advances now being made in avionics.

Because of the growing importance of avionics and the key role in its technical progress played by the Air Research and Development Command, AVIATION WEEK presents this special report: "Avionics in the Air Force." This report was written by AVIATION WEEK'S Avionics Editor, Philip Klass, after a personal tour of all the major Air Force avionic research and development centers and personal interviews with the leading military and civilian technicians in this field.



Rome Guides AF Avionics Development

Ground-based avionics is RADC's broad assignment; new program aims at developing an integrated system for tactical air power

By Philip Klass

Rome, N. Y.—The Air Force has recently launched an important new program to develop an integrated avionic weapons system for tactical air power. The system will be specifically designed around Tactical Air Command's assigned mission of local combat area defense, interdiction, and ground support.

The responsibility for this significant new program has been assigned to the Rome Air Development Center here at Griffiss AFB under the command of Brig Gen Daniel C Doubleday—AF's Cambridge Research Center and Wright Air Development Center support this effort.

▶ **Centralized Intelligence**—The system will be designed to provide a TAC field commander with centralized intelligence and control. Data on enemy disposition will be funneled automatically into this control point from far-flung mobile radar stations and processed in automatic computers.

The commander will analyze this digested intelligence and decide his strategy and tactics. Aircraft will then be directed from this central control point, possibly automatically via a radio data link (telemetering).

▶ **Logical Choice**—RADC, with its experience in ground and ground-air electronics, was a logical choice for this TAC control system assignment because the system will involve ground-based radars, communications, and automatic computers, all of which are right up RADC's alley. Also, TAC's local area air defense problem closely resembles the continental air defense problem on which RADC has been working for several years.

A recent top-level USAF decision merged RADC's air defense activities with those of the AF Cambridge Research Center and Project Lincoln, under the over-all supervision of Cambridge.

Many of the air defense system techniques can be applied to the TAC system although it must be designed to provide greater mobility for use in forward combat areas.

▶ **Airborne vs. Ground-Based**—The prevailing philosophy at RADC is that many navigation functions now performed by airborne equipment should be handled by ground-based avionic equipment. Airframe manufacturers, always glad to get weight out of their airplanes, are bound to applaud this philosophy, although there is another side to the argument which will be discussed elsewhere in this issue.

RADC says that the necessary techniques are now available to eliminate most of the airborne navigation and landing-aid equipment from future TAC aircraft. RADC intends to apply this philosophy to the fullest in its TAC system.

Rome Responsibility

Rome's broad assignment in the ARDC is to develop and/or guide the development (by outside contractors) of all Air Force ground-based avionic equipment—with several exceptions.

Thus RADC responsibility includes ground-based equipment for navigation, communication, direction-finding, missile guidance, electronic countermeasures and airborne IFF (identification, friend or foe).

▶ **Wide Range**—RADC's activities encompass a variety of equipment from huge million-dollar radar stations for air defense to tiny UHF radio transmitter/receivers which a ground controller can pack on his back and use to direct ground-support aircraft from the front lines.

Last year RADC sponsored $18 million in outside avionic developments. During the same period, the Air Materiel Command purchased over half a billion dollars worth of production items in the ground-based avionic field.

▶ **Exceptions**—One partial exception to this broad statement of RADC responsibility is found in certain equipment used by two or more branches of the military service.

However, even here RADC is not completely relieved of responsibility.

The Air Force uses standard Signal Corps-developed HF gear for fixed ground stations, but the equipment is too heavy and bulky for some vehicular applications such as mobile controllers mounted in small jeeps. For these vehicular uses, RADC must provide suitable equipment. In the interest of standardization, RADC adapts small airborne HF equipment developed by Wright Air Development Center in Dayton for vehicular use.

▶ **Project Lincoln**—Another exception is found in the air defense program where overall system responsibility has been assigned to AFCRC.

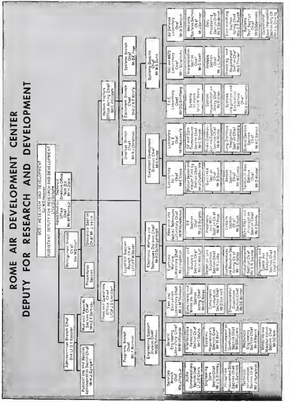
Production engineering of specialized equipment developed by Project Lincoln will in the future be sponsored by AFCRC, although some of it may be supported by RADC.

AF Experiment

Griffiss AFB at Rome represents an Air Force experiment in centralized operations.

Approximately two years ago the Air Force decided to move its Air Materiel Command functions (purchasing, sup-

Brig Gen Daniel Campbell Doubleday ... commander, Rome Air Development Center ... specialist in electronics and atomic weapons ... born Johnstown, N Y, 1905 ... graduated U S Military Academy, 1929 ... flew fighter in prewar pursuit squadrons ... was chief of radio and radar section in AAF Hq ... served overseas as deputy communications officer of the Far East Air Forces ... was postwar chief of scientific liaison section in AAF Hq research and engineering division ... director of R&D division of Armed Forces Special Weapons Project (atomic) ... appointed deputy director of special weapons development at Sandia and later was chief of the development field command there.


ROME AIR DEVELOPMENT CENTER
DEPUTY FOR RESEARCH AND DEVELOPMENT

One of the Alcoa operated forging presses —and a part of the company's "big press program." Here, a 15 000 ton "squeeze" gives aircraft designers a new freedom in design concept.

ply, and maintenance) for ground based avionics from Wright Patterson AFB, Dayton, to Griffiss For a little over a year now these AMC activities have been centered in the Rome AF Depot under the command of Col M F Summerfelt

► **Engineer "Midwives"**—There were many logical reasons for such a move When an equipment has gone through its development phase, and the Air Force wants to put it in production, AMC must lean heavily on ARDC engineers These men have lived with the project since its inception and thus can give AMC technical guidance in preparing equipment specifications

Later the ARDC engineers may move into the contractor's factory to act as "midwives" until the first units have come off the line

Still later, the ARDC engineers serve as consultants on major maintenance and field usage problems for the service life of the equipment

General Doubleday sums up RADC's responsibilities "We live with the equipment from the 'cradle to the grave' "

History

The majority of RADC's technical personnel were members of Watson Laboratories, set up as a Signal Corps lab at Ft Monmouth, N J, during World War II to handle ground based avionics for the then Army Air Force

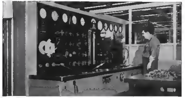
After the war, Watson Labs were transferred to the newly formed USAF, and in the winter of 1950, this group was transferred to Griffiss AFB at Rome

► **Congested Airways**—A major purpose in relocating the Watson operation was to get it away from the congestion of main airways in order to prevent experimental radar, communications, and flight test aircraft from interfering with commercial air traffic

Griffiss AFB at Rome, which had been built in 1941 as an AF maintenance depot, met this off-the-way-airways requirement and was available. In 1950, GAFB was serving primarily as a storage facility

► **Dissension in the Ranks**—When the move was first proposed in 1948, several groups of employes went to Rome to scout the area When they returned they reported that the community compared unfavorably with their existing suburban living on the fringe of greater New York

As a result of these reports, some of the employes organized to lobby against the move and raised enough opposition to block it temporarily The invasion of Korea served to break this roadblock



Greer Stationary Hydraulic Accessories Test Stand, shown here in Ford's Kansas City Aircraft plant, provides a shop type machine to fully check hydraulic system accessories including system pump at flow rates up to 20gpm and at pressures up to 3400psi.

Greer Dual Hose Tester, used for B-47 hose lines, checks from one to six hose lines or similar production components with pressures to 25,000psi in covered burst chamber

Greer Portable Hydraulic Test Machine provides hydraulic test fluid for checking hydraulic systems of modern aircraft Handles flows up to 20 gpm and pressures up to 3400psi

■ ROME

and the move to Rome began in November 1950 and was completed by spring the following year.

When the chips were down, almost 75% of the technical and professional employes decided to move to Rome.

▶ **When in Rome**—After two years in this medium-size up state community, conversations with RADC personnel give the impression that many now would be reluctant to return to Ft. Monmouth. Rome is only a few minutes drive from many lakes and the Adirondack Mountains.

A local chapter of the Institute of Radio Engineers has been formed, and the University of Syracuse sends professors to Rome to conduct classes for advanced degrees.

RADC people are becoming active in local community and civic affairs.

Personnel

Today there are approximately 7,500 military and civilian personnel stationed at Griffiss, of whom roughly 4,000 are assigned to RADC. The remainder belong to such tenant organizations as the AMC depot and the 27th Fighter Squadron (flying F-86s) of the Air Defense Command.

Col Franklin Paul
Vice-Commander

There are approximately 800 civilians and 100 military personnel who are directly involved in RADC's technical mission, under the command of Col. W. S. Heavner, Deputy for Research and Development. The rest of the RADC manpower performs supporting functions and operates the base.

▶ **Technical Degrees**—A breakdown of the 900 people under Col. Heavner shows there are about 300 civilian engineers and scientists, and 60 officers, most of whom have degrees in engineering or science.

Col. Heavner himself has a master's degree in electrical engineering and in management.

Lt. Col. O. J. Schulte, assistant deputy, has a B.S. in E.E. The civilian technical director of R & D is Harry Davis whose record shows a B.S. in physics and an M.S. in electrical engineering.

RADC Activities

RADC's technical manpower is applied to three major types of activities in approximately the following proportions:

- 50%: **Guidance of developments** of outside contractors and analysis of the results of outside study contracts.
- 12%: **In-the-house development** of new ideas and techniques to establish their merit.
- 38%: **Support of AMC procurement**. This involves preparing specs, following pilot runs of new equipment at contractor's plant, introducing new equipment in the field, and helping to set up off shore procurement in foreign countries.

▶ **More in the House**—Although RADC acknowledges the need and importance of its AMC support and outside development guidance activities, its people

■ ROME

wish they could do more in-the-house development. For one thing, RADC recognizes that such development is necessary to maintain the technical competence of its personnel.

Unless RADC (and other ARDC centers) engineers have a first-hand knowledge of new technical developments and techniques in the fast-moving avionic field, they can't do the best possible job of guiding developments by outside contractors.

Another equally important justification is that RADC engineers can try certain new ideas on a "haywired breadboard" basis in their own labs in less time and at less cost than if the work were contracted out.

▶ **Convincing "Doubting Thomases"**—Davis points out that in-house developments can be used to convince doubting contractors that it is possible to meet RADC requirements or that an idea is feasible. As an example, Davis cites a tracking computer which originally used 125 vacuum tubes.

Despite RADC's urging that the device could and should be redesigned to reduce the number of vacuum tubes (and thus its size, weight and complexity), the manufacturer was unconvinced. So RADC engineers stepped in and redesigned the computer themselves and now it requires only 15 tubes.

▶ **One Big Workbench**—The very nature of RADC's radar and radio work demands that much of its laboratory experiments be performed out-of-doors. RADC now has 11 test sites located around its 2,500-acre base and another eight sites off base—two of these are located more than 1,000 mi. away.

All of the on-base sites are supplied with base power and communications, and major sites are interconnected with coaxial cable to permit remote transmission of radar/microwave signals.

"The whole base is a great big workbench," Gen. Doubleday says.

Off-Base Sites

Most of the outdoor sites had to be carefully selected for their topographical layout and/or location, as well as their technical characteristics, such as being free from man-made static. For example, the 1,200 ft-high radio tower which RADC constructed for low-frequency, long-range navigation work, presents an obvious hazard to low flying aircraft and so is located at Forestport, N. Y., some 40 miles northeast of the air base.

RADC needed a unique site to check the radiation patterns of radar and radio antennas without picking up stray reflections from the ground. They found an ideal spot about 20 miles east at Newport, N. Y. The transmitting antenna

Col. William Heavner
Deputy for R&D

under test is placed on one high cliff and the receiving antenna on another. The intervening gully prevents ground reflections.

▶ **Other Off-Base Sites**—In addition to the Forestport and Newport facilities, RADC operates the following off-base sites:

• **Floyd, N. Y.:** An unobstructed "static free" location approximately three miles east of GAFB used to check direction finding and communications equipment.

• **Verona, N. Y.:** Primarily a ground radar test site 12 miles southwest of GAFB, which is used for TAC weapons system and electronic countermeasures studies.

• **Jervis Ave. (Rome):** An omnirange and short-range navigation test facility located about two miles west of GAFB.

• **Adamston, N. J.:** A long-range, low-frequency navigation test facility.

• **Carrabelle, Fla., and Cape Fear, N. C.:** Test sites for navigation system studies.

Environment Chambers

When new environmental test chambers now under construction are completed this year, RADC will be able to drive a large trailer, housing a mobile radar or other avionic equipment, into a test cell and run the temperature down to −70F or up to 190F, under humidities of 10% to 95%. This 16 x 32 x 17-ft. temperature-humidity room will have a volume of approximately 8,750 cu. ft.

▶ **Hot and Cold**—Eight other large walk-in type chambers are under construction in the same building, formerly used as a test cell for aircraft engines. These include four arctic rooms and four tropic rooms, varying in size from 400 to 1,200 cu. ft.

■ ROME

The tropic chambers will provide temperatures of 34F to 190F and humidities of 10% to 95%, except for one which can create 100% humidity conditions (rain)

The four arctic rooms can be operated at temperatures of −70F to 72F, and one of them can also provide simulated altitudes up to 70,000 ft.

▶ **Explaining the Altitude Chamber**—An altitude chamber may seem like an unnecessary addition at a center devoted to ground-based avionics, but there's a logical explanation. Much of RADC's ground based equipment must be capable of being transported by air and thus must be able to withstand exposure to high altitudes

Current AF ground based avionic equipment specs call for withstanding exposure at 60,000-ft altitudes although this is considerably beyond the normal cruising altitudes of existing AF transports

There is still another altitude factor to consider. Ground-based equipment may be used on terrain many thousands of feet above sea level, and so must be capable of operation "at altitude"

▶ **Chamber Facilities**—Test chamber temperature and/or altitude conditions will be capable of being programmed in advance to give any desired cycle of environmental conditions

Observation rooms adjoining the chambers will enable engineers to observe the equipment under test These rooms are air conditioned so that test equipment can be operated under controlled conditions

Many types of power are available in the test chambers to accommodate a variety of equipment Supply voltages and their frequencies can be adjusted over a range of 10 20% to check equipment operation under low and high voltage and frequency conditions In addition to 28 v d c power, 120/208 v a c power will be supplied at 400 cps, 120 cps, 60 cps, and 25 cps

Lt Col. O J Schulte
Asst Deputy for R&D

Harry Davis
Technical Director

■ ROME

Avionics Team Spends Half a Billion Dollars

Rome, N. Y.—From a contractor's viewpoint, the location of both Air Research and Development Command and Air Materiel Command ground based avionics functions here at Griffiss AFB means that "all roads lead to Rome."

In a single visit, a contractor interested in ground-based avionics can talk with Rome Air Development Center engineers, RADC procurement people, and/or AMC procurement, supply, and maintenance personnel

▶Two Groups—The two procurement groups at Griffiss are separate and distinct. One, under Lt Col P L. M. Packard, is a part of RADC and buys only research and development The other, under Lt. Col. J M. Cryer, is a part of AMC and buys production versions of ground based avionics equipment developed under RADC sponsorship.

In addition to its obvious convenience, the Griffiss AFB centralized arrangement makes it easy for a contractor to round up all persons involved in a knotty production problem to obtain a quick on-the-spot decision

RADC Procurement

Last year approximately 125 prime contractors, including 25 colleges and universities, shared the $18 million in development and study contracts let by Rome Air Development Center, Packard told Aviation Week The typical R & D contract price is in the neighborhood of $50 100,000, although a few very large contracts would raise the average price to a slightly higher figure.

▶Industry and University—Generally speaking, contracts that involve development (and delivery of prototype equipment) are awarded to industry while basic research and study contracts go to universities, although there are exceptions in both cases. The typical industrial R & D contractor has 100-1,000 employes, Packard says

Asked about the types of contracts used for RADC procurements, Packard gave the following breakdown of last year's contracts

- 51% Fixed price with redetermination
- 11% Fixed price.
- 25% Cost plus fixed fee (CPFF).
- 13% Cost reimbursement

The cost reimbursement type contract is similar to the CPFF type but involves no fee or profit to the contractor This type is frequently used for basic research contracts with universities

▶R & D Buying Philosophies—All Rome Air Development Center research and development procurements are negotiated types (rather than bid types frequently used for less complex, standardized production items) In selecting contractors, RADC uses the following philosophies established by ARDC headquarters

- **Basic research.** Technical evaluation of contractor's capabilities and know how should override price considerations
- **Development.** Technical evaluation plus business evaluation and production capabilities (where appropriate) should be major considerations

Price should be of secondary importance in evaluating both research and development proposals

Another guiding philosophy is that research procurement functions should be in the closest physical proximity to the RADC project engineer and the engineer should have full responsibility for the program.

To assist the engineer in carrying out this responsibility, the procurement office administers all R & D contracts it negotiates This is designed to assure quick, efficient coordination among the three parties involved—the contractor, the project engineer and the contracting officer

▶Contractor Relations—Prospective new contractors interested in ground based avionic R & D work may register at RADC's contractor relations branch, which will in turn arrange for conferences with RADC engineers in the contractor's field of activity In this way a contractor can learn of RADC's present needs and projected programs

The list of registered contractors is cross-indexed according to their fields of interest When a new R & D program comes up for procurement, the procurement office sends out Requests for Proposal (RFPs) to qualified contractors on its list.

Should a manufacturer fail to submit a proposal or to acknowledge receipt of three or four successive RFPs by writing to decline to submit a proposal, the

■ ROME

procurement office usually contacts the contractor to see whether he still wants to remain on the RADC lists.

Normally a contractor is given 30 days to submit a proposal, and up to 60 days may be allowed if the program involved is extremely complex, Packard says.

▶ **Specification Conferences**—Upon receipt of the RFP and its associated exhibit (technical specification), contractors frequently send their representatives to Rome for discussions with RADC engineers. The purpose of such meetings is to get answers or an official interpretation to their questions on the specifications.

New techniques are being tried involving very complex equipment where all interested contractors are invited to attend a joint spec conference at RADC, according to Packard. Engineers from several companies go over the specs line by line with RADC engineers, asking questions and suggesting minor revisions. The latter are incorporated in a revised spec which goes out with the RFPs shortly afterward.

As a result of this preliminary conference, the prospective contractors are ready to go right to work on their proposals from a common starting point and with uniform interpretations when the RFP and revised spec arrived.

RADC Evoluotion

"How do you evaluate these technical proposals?" AVIATION WEEK asked Packard. He indicated that the technical proposals, which have no pricing information in them, are submitted to the project engineer to be rated on the following points

Lt. Col. P. L. M. Packard
Chief, R&D Procurement

■ ROME

• **Feasibility** of approach proposed by the contractor.
• **Insight into problem,** as evidenced by contractor's proposal.
• **Previous experience** of contractor in this or related fields.
• **Contractor's reputation** in research and development (Does he normally meet delivery dates? Specifications? Does he habitually ask for spec waivers after the program is under way?)
• **Effect of spec exceptions** (requested by contractor) on the end item.
• **Production capabilities** of the contractor in the event production is eventually planned and the developing contractor might be logical producer.

After rating each proposal on the six points cited above, the project engineer evaluates their over-all technical merit and rates them relatively, i.e., first, second, third, etc. There is no predetermined weighting factor for any of the six points. This will depend upon the RADC engineer's evaluation of their importance for the particular project.

▶ **Business Evaluation**—Meanwhile the procurement office has been analyzing the business aspects of each proposal, taking into account such things as price, type of contract requested, and the profit or fee percentages sought. The PO in turn ranks the proposals in order of overall business merit.

When both ratings are complete, the procurement office and project engineer sit down and compare results. If the best technical proposal is also the lowest priced, or nearly so, the decision is easy. Sometimes the comparison is more difficult because one contractor has made his proposal based on a CPFF type contract and another has based his on a fixed price-with-redetermination type contract.

▶ **Hard Choice**—In this case, if the race is close, the PO may ask each contractor to submit a new financial proposal based on the other type of contract—to put the comparison over a common denominator.

Packard says that his office is considering steps to broaden the base of technical assessment of RADC proposals by seeking evaluation by the responsible section, laboratory, and division chiefs as well as the project engineer.

AMC Procurement

Processing of a purchase request for ground-based avionic equipment which used to take 30-60 days has been cut to 7-10 days since AMC moved its procurement, supply, and maintenance functions to Rome, according to Col. M. F. Summerfelt, commander of the Rome AF Depot.

He attributes the speedup to new contract-paper routing techniques that

■ ROME

are possible in a smaller tightly knit operation and to the close proximity (two minutes walk) of RADC engineers

Prior to the move from Dayton about a year ago, RAFD was a small supply depot handling three classes of material Today the Rome Depot stocks 12 classes Summerfelt compares the task of expanding the previous Rome Depot to the problem of "converting a country store into a supermarket."

Only about half of the present 2,200-man Rome Depot staff made the move from Dayton The rest had to be recruited locally and trained, a big job according to Summerfelt

RAFD Job

Rome AF Depot has the triple responsibility of procurement, supply, and maintenance for ground based electronics, certain electrical items like lights and cable, and photo supplies. A breakdown of RAFD personnel shows approximately 150 in procurement, 500 in maintenance, and 1,500 in supply

▶ **Half a Billion**—Last year RAFD purchased approximately $540 million worth of production equipment and items from about 500 prime contractors The majority of these contracts were fixed price, although some of the larger ones included provisions for price redetermination, Summerfelt says RAFD's contractor relations office lists about 3,100 prospective contractors

The Rome Depot pushes competitive bidding wherever possible, but the complex nature of some of the avionic equipment it buys restricts this objective, Summerfelt admits.

Last year approximately 85 RAFD contracts were let on the basis of Invitations for Bid (IFB) and approximately 1,200 were awarded on the basis of Requests for Proposal (RFP) or Requests for Quotation (RFQ).

Maintenance Engineering

RAFD's directorate of maintenance engineering has the responsibility for directing equipment overhaul shops, located at Rome and monitoring the overhaul of similar items at other AMC depots

Presently studies are underway to determine the feasibility of absorbing a larger workload here

▶ **Other Responsibilities**—In addition, maintenance engineering has the responsibility for engineering review of communications and radar installations, on a worldwide basis, preparation of handbooks (operation, maintenance, and spare parts catalogues), and the handling of unsatisfactory reports (URs) on equipment failures in the

(Advertisement)

Valve Talk

for WM. R. WHITTAKER CO., Ltd.

by Marvin Miles,
Senior Member, Aviation Writers Assn.

"The Air Research and Development Command does an outstanding job . . ."

Dell Phillips spoke slowly and emphatically, then added:

"We couldn't function without their continuous help. They keep our thinking straight. The concepts of aircraft can change so rapidly—supplier development phases can gain or lose importance so quickly—that we must keep in close touch or we might sneeze and miss something."

A Whittaker vice-president, the tall, matter-of-fact engineer is the company's idea man. His spotless lab, filled with watch-like intricacies, is called the "Dream Room" and represents the company's own research and development command.

Here, through the medium of humming machines and precision work, the Phillips ingenuity is transformed into actuality, abetted by a select crew of technicians chosen not only for exceptional mechanical ability, but for what Dell calls "development perspective."

Usually there are half a dozen projects going on at once, developments conceived by Dell to meet specific needs in keeping with aircraft progress or to better existing units. Here too you're likely to see innovations that may change entire concepts in valve and related fields. And from these projects may come unanticipated developments, some born of necessity in furthering creation or test in the major lines of Dream Room work.

ARDC on a small scale

In a small way, Dell's lab is somewhat like ARDC. The Air Force command is exploring years ahead of the field, delving, testing, proving, charting a course for military aviation to follow in achieving performance with safety.

Performance with safety—these words characterize the ever-demanding goal of ARDC. Their daily routine probes the many challenges of flight, in streaking aircraft, in wind tunnels and laboratories, on drawing boards and in the minds of men with vision and courage.

Intrigued by the challenge and restless with ideas, Dell, himself, works far ahead of the field with quiet determination to turn out performance—and with it safety through dependability.

In his laboratory today, for instance, an amazing new fuel pump is under development, the result of his impatience with the cumbersome weight and inefficiency of standard types. Compact and revolutionary, it's already drawing widespread interest.

And from this project came a by-product in the form of a highly sensitive meter for measuring vapor/liquid ratio. Designed and created out of necessity to check the pump's performance, it's the only instrument of its kind and has been turned over to the Wright-Patterson engine division.

"Try to remedy it first"

Dell has the typical zeal of the inventor, combining curiosity and skill, patience and perception, with a sort of sixth sense in ideas. These he mixes with a philosophy that he shouldn't beef about a situation until he's tried to remedy it. That's why one of his current projects is to develop a bearing that will take high r.p.m. and extreme temperatures—without lubrication.

"For years we've been far too close to temperature maximums in bearings for hot air valves," he explained. "Why not find something that will give us ample leeway and eliminate lubrication? We're working on it . . . and it looks like we've got it."

The laconic 39-year-old engineer welcomes challenge, like the time when an Air Force engineer asked him if there was any possible way to split a flow stream evenly. Dell didn't know, but he was eager to try. After kicking the problem about in his mind for a time, he started by simply bolting a couple of standard water meters together. From this evolved Whittaker's current flow divider used on the Douglas C-124 oil system.

But Dream Room projects are not all successes—far from it. Dell is the first to admit his failures. He points to what he calls his "junk pile," representing ideas that haven't worked out.

"In a way it's a measure of how we're doing," he explains. "If we keep the ideas going, we're bound to hit now and then. No junk pile means no ideas. When we don't have a pile, I'll really start worrying."

■ ROME

field. When URs indicate a fundamental shortcoming in equipment design, maintenance engineering sets up a project to investigate the necessary "fix" with RADC engineers who in turn bring in the equipment manufacturer.

RAFD likes to contract out much of its overhaul work to the original equipment manufacturer.

In many cases, however, manufacturers find it difficult to gait their normal production line operations to handle the sporadic overhaul work load, Summerfelt says. This is one reason why RAFD does some of its own overhaul work; another reason is that the Depot must have a capability of maintaining every type of equipment for which it is responsible. This also enables local engineers to examine equipment in detail.

Thus, RAFD has a "fire brigade" shop for what is required here or overseas.

Depot Supply

The RADF directorate of supply and service has the task of seeing to it that an adequate stock of ground-based avionic equipment is always on hand, as well as a sufficient quantity of the right spare parts to keep operating.

▶ **Guessing Right**—A bad guess on future Air Force needs could be disastrous. If you find yourself short of, say, a dozen radars, you don't go out and buy them off a dealer's shelf like TV sets. Lead time on big radar sets is currently running about 2-2½ years.

To establish a sound basis for its future procurement, the supply directorate examines:

- Last year's usage.
- Present inventory.
- Repairable equipments on hand.
- Programmed AF size.

If the equipment is new, and there is no previous experience to work from, Rome Depot seeks advice from RADC engineers and manufacturers.

This directorate also operates the warehouse at Rome and monitors the Western AF Depots in distribution of their prime classes of property. RAFD is currently building a $2 million warehouse and overhaul shop for avionic equipment at Rome. When completed next year, RAFD will have over two million sq. ft. of warehouse floor-space.

Everyone, both in Rome Air Development Center and Rome Air Force Depot (AMC) seems to like the integrated Griffiss AFB set-up.

The single mission at GAFB—developing, producing, and fielding the best possible ground-based avionics—produces a unity of purpose. The base is small enough for individuals to see how their efforts dovetail into the over-all operation. These are factors which produce good esprit de corps.

FIRST CLOSE-UP of K-System shows optical sight (center) and radar scope (left).

Ten Years for a Bombing System

In 1953, Gen. James H. Doolittle announced: "We have progressed in our bombsight development to the K-System, long a secret. It weighs 1,700 lb., contains 365 vacuum tubes, costs $200,000. It links automatic sighting with automatic navigation, permits highspeed bombing at night through the overcast with greater accuracy than former daylight methods at half the altitudes and speeds."

Here, for the first time, are photographs of the K-System, developed by Sperry Gyroscope Co. together with a date-by-date history of the birth of the bombing system used in our B-36s and B-47s. The chronology that follows shows that it takes almost 10 years to develop, design, get into production, and place a new complex avionic system in tactical use.

1942-43: Extensive use in World War II of three existing bombsights demonstrated their limitations for modern use.
- Missions sometimes return without ever finding the cloud-covered target.
- Even with fair visibility, camouflaged targets make recognition difficult.
- Straight and level bomb run of 30 seconds or longer is needed, making airplane vulnerable to air and ground fire.

1943: Sperry Gyro seeks entirely new concept, in close collaboration with Air Force. Forms special group to initiate "high altitude bombing studies" and research—with Sperry funds. Studies point to need for completely automatic system, to eliminate complex human manipulations, with navigational computer as part of the system.

1944: Sperry reports findings and proposes an automatic bombing and navigation system to Air Materiel Command. AMC awards letter contract to Sperry for two experimental "K-Systems."

1945: Design and development under way on first prototype K-System. Complex electro-mechanical design indicates need to develop new manufacturing techniques.

1946. Detailed layout and bread-board stage, with last minute design improvements to aid producibility.

1947: Engineering consultations on radar sighting with Bell Telephone labs, on optical components with Perkin-Elmer, Farrand Optical Co., and Massachusetts Institute of Technology. AMC awards Sperry a production contract to build 13 additional systems.

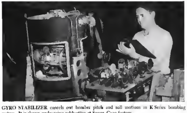
1948: First K-system installed in a B-29 and tested by Sperry engineers at MacArthur Field, L. I., dropping 100-lb. practice bombs. "Amazing precision" achieved, with a single operator functioning as navigator, radar man, and bombardier. This is followed by evaluation tests at Eglin AFB, Fla. Five preproduction K-systems sent to AMC.

1949: Improved system, incorporating polar navigation control for use at high latitudes, installed and tested in B-50. Polar navigation control performs very accurately. First 13 production systems delivered and AMC orders hundreds more. To broaden production base, Sperry assists AMC in setting up A. C. Spark Plug, National Cash Register, and International Business Machines, as well as General Mills and Eastman Kodak, on optical components.

1950: Accelerated service test on early production K-system in first B-36. Other B-36s, equipped with early K-systems, assigned to SAC 7th and 11th Bomb Wings at Carswell AFB, where operational shakedown shows need for certain improvements.

1952: More than 300 K-systems now installed in USAF aircraft.

1953. Air Force and Sperry finalize designs for a new, improved bombing system to succeed the K-series.



GYRO STABILIZER cancels out bomber pitch and roll motions in K-Series bombing system. It is shown undergoing calibration at Sperry Gyro factory.

POLAR NAVIGATION converter makes possible accurate world-wide navigation.

WIDE RANGE of RADC activities is evidenced by 1,200 ft. antenna, left, and tiny portable transceiver, right, used to instruct ground-support aircraft

Rome Expands Role of Ground Avionics

RADC's advances will have a major impact on military air power, may soon spill over into civil air operations.

Rome, N. Y.—Important new and expanded roles for ground based avionic equipment are being created here at the Rome Air Development Center which will have a major impact on military air power and could, within 10-15 years, have a similar effect on civil air operations and traffic control.

▶ **Landing Jets**—RADC is working on a major problem plaguing all of the Air Force's operating commands and one which will worry the airlines, on a somewhat milder scale, when they start flying jets.

The military problem is this: How do you schedule the orderly approach of dozens of jet aircraft, returning to their bases with near-empty fuel tanks, so that each plane arrives in position for its final approach at the proper time?

If you can save five minutes of low-altitude delay in landing, you give a jet fighter another 10-15 minutes in combat. Or if you can double the number of bombers which can be landed at one airfield in a given interval, you eliminate the expense and trouble of building additional runways and/or airdromes.

▶ **Return-to-Base Computer**—In cooperation with WADC and AFCRC, Rome is engaged in development of a return-to-base computer which instantly and continuously calculates the optimum flight path and arrival time for every aircraft within a suitable distance of an airdrome to assure a close and orderly sequence of arrival. The computer operates from data provided by ground-based radar giving information on the position, heading, speed, and altitude of every aircraft in the area.

Individual guidance instructions to bring each airplane in at its prescribed time will be transmitted automatically via radio telemetering equipment (data link) and will be displayed in the cockpit. These signals also can be fed to the plane's autopilot, enabling the ground station to maneuver each airplane automatically in the desired flight path.

This computer is only one portion of an overall automatic traffic control and landing system.

As planes are funneled into the final approach position, an automatic ground controlled approach (AGCA) system will take over and give the pilot ILS-type cockpit guidance as well as aural talk-down instructions. Or the AGCA will control the plane's approach path via its autopilot approach coupler. (AGCA, developed by Gilfillan Bros., Inc., under RADC sponsorship, is currently going into pilot production.)

To provide completely automatic all weather landings, RADC is also investigating a ground based system to provide automatic flare-out and landing at the point where ACCA control terminates (normally 50-100 ft. from the ground).

▶ **TAC Weapons System**—RADC has recently taken on an even bigger assignment to develop an integrated weapons system for the Tactical Air Command. TAC's tasks of interdiction and ground support pose serious problems which will require RADC to dig deeply into its bag of avionic tricks.

The TAC system will give RADC an opportunity to prove its basic philosophy that many navigation and guidance functions now performed by airborne avionics equipment can be better performed by ground-based avionics. RADC officials say their objective is to make a single airborne black box—a transmitter/receiver—to provide the pilot with all required guidance, navigation, communications, and landing information via a radio data link.

▶ **Sub-System Efforts**—A major portion of the R&D efforts at RADC go into ground based sub systems such as radars, computers, communications, and data links. These are the building blocks from which the "super-systems" are constructed. Approximately 80% of this R&D work is performed by outside contractors, under RADC guidance, the balance is done "in the house."

Broadly stated, these sub system efforts are directed toward:

- **Improving performance** of existing techniques and equipments.
- **Developing new techniques** and equipment to meet present tactical needs.
- **Exploring new areas** to build up know-how to be able to meet future tactical needs quickly.

▶ **Range and Resolution**—In the first

area, for example, RADC is devoting much effort to improving the range and accuracy (resolution) of ground based radars. In the second area, to meet the needs of automatic control systems which must operate from radar signals without human interpretation, RADC is working to improve radar's ability to discriminate between real targets and spurious signals from the ground or other fixed objects.

Other developments in this area include long-range, high accuracy navigation systems, aimed at pinpoint accuracy for bombers and guided missiles. Also, data link techniques for transmitting guidance and navigation information to a multitude of aircraft without cluttering the narrow radio spectrum are being developed here.

The third area, developing know-how to meet future needs, is typified by RADC's work in electronic countermeasures, where it must develop knowledge and techniques to be able to counter quickly any enemy jamming.

► **Handling "Super Systems"**—Developing, and guiding the developments of industrial contractors, in this comparatively new field of "super systems" has raised serious organizational problems. Close integration of the characteristics of all sub-systems is imperative to assure their compatibility when connected into super systems. Yet there can be no deemphasis on the individual sub-system developments since their performance limits that of the "super system."

Last January RADC completely revamped its research and development organizational setup to handle the new super systems without neglecting the vital sub-system building blocks.

Under the old setup, R&D had been divided into five laboratories: communications, navigation, radar, data handling (computers), and general engineering. The trouble with this organization structure was that the new super systems cut across the lines of responsibility of all of these laboratories, making it difficult to place overall system responsibility in any one.

► **Streamlined Organization**—For many months RADC personnel studied the organizational structures of military and industrial laboratories, looking for a suitable organization pattern, Lt. Col. O. J. Schulte, assistant deputy for R&D, reports. These included the Signal Corps, Naval Research, General Electric, Radio Corp. of America, and Bell Telephone Laboratories.

RADC found no pattern which suited their specific needs, Schulte says, but it received many ideas that could be useful in developing the new R&D structure.

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The new streamlined R&D organization consisting of eight laboratories and one services branch is grouped into the following four divisions

- **Systems.** Responsible for integration of sub-systems into super systems and tailoring these super systems to the needs of various operating commands (TAC, ADC, SAC, and MATS).
- **Equipment Development.** Responsible for developing and supervising the development by outside contractors of sub systems such as radar, direction-finders, radio communications, long-distance navigation, and data link.
- **Electronic Warfare & Techniques.** Responsible for developing ground-based electronic countermeasure techniques and equipment as well as exploring new techniques applicable to all types of ground based avionic equipment.
- **Engineering Support.** Responsible for providing general engineering services such as drafting, test instrumentation and mechanical design and test laboratory facilities for evaluation of equipment developed for RADC.

▶ **Semi-Autonomous Operation**—RADC has set up each division to operate with the greatest possible autonomy. Whereas administration functions previously had been performed for all labs by a single separate division, each of the four divisions now has its own administrator and Plans and Operations section for handling administrative and financial affairs of the division. A central P&O office, under the deputy for R&D, handles only those problems that cut across divisional boundaries, Schulte indicates.

Wherever possible R&D functions have been decentralized. For example, representatives of the operating AF commands (SAC, TAC and ADC), who were formerly in the Requirements Branch of the Central Plans and Operations Office, recently have been transferred to the Systems Division where they can be closer to systems planning to direct R&D activities toward their tactical needs.

When the new R&D structure went into effect, RADC reshuffled as many as possible of its existing programs to fit them into the new setup. A few programs, which would have suffered by a midstream transfer, were continued under the old setup. However all new projects that have come in since January have been assigned under the new organization structure.

▶ **Meets Individual's Needs**—Schulte believes the new organization is better suited to the professional needs of individual RADC engineers. He points out that some technical people like to become long-haired researchers in a narrow segment of their field, they don't want to be "bothered" with converting ideas into tactically useable "hardware." This type of man would find the Research and Applied Techniques Laboratory of the Electronic Warfare and Techniques Division to his liking, Schulte says.

Other engineers want to be specialists in broader fields, like traffic control radar, communications, or computers. These men usually like to get their hands on actual equipment and work it; they find their niche in the Equipment Development Division. There are still others who are not too interested in the internal design details of a radar, or a computer. Instead, these engineers prefer to apply these sub systems to the solution of large-scale tactical problems. These men find a home in the Systems Division.

To get a more detailed picture of RADC's current activities and accomplishments, AVIATION WEEK talked with many of the division and laboratory chiefs. Here, within the limits imposed by security, is the picture.

Systems

The Systems Division functions, in many respects, as an engineering staff for the various AF operating commands, i.e. Strategic Air Command, Tactical Air Command, Air Defense Command and Military Air Transport Service. The Systems Division's job is to find out what tactical problems face the operating commands and then to figure out how ground-based avionic techniques can be applied to solve them.

Another major objective for this division is to see that RADC sub-system de-

Warren S Dunn
Chief, Systems Division

AVIONICS

velopment efforts are directed toward specific tactical needs The Systems Division will be able to exercise this control by drawing the pursestrings tight on any project which has no potential tactical use On the other hand the division must be constantly alert to areas where development work is needed in order to provide the necessary building blocks for its super systems.

▶ **Systems Division Organization**—Warren S Dunn, a veteran of a dozen years with RADC and its predecessor labs, heads the 100-man Systems Division Of this number, approximately 50 are civilian engineers and 10 are military personnel with technical backgrounds. The group is subdivided into three laboratories according to the operating command for whom they work

- **Tactical Air Command lab**
- **Strategic Air Command and Military Air Transport Service lab**
- **Air Defense lab**

The TAC lab gets approximately 50% of this division's efforts, and the other half is divided approximately equally between the other two labs, Dunn reports However, he adds that this breakdown is subject to change as new programs come in and old ones are finished off

The Systems labs normally look to the Equipment Development Division and its outside contractors for all of the basic building-block subsystems which make up the super (weapons) systems One exception is what RADC people call "green boxes." These are special "black boxes" needed to tie together standard equipments into super systems By allowing Systems Division engineers to develop or guide the outside development of "green boxes," systems engineers maintain their technical competency and avoid becoming mere paper planning engineers

▶ **TAC Lab Activities**—The new weapons system under way in the TAC lab is intended to keep a TAC field commander continuously informed as to the disposition of his own and enemy aircraft and ground forces Information from mobile radars and ground observers will be funneled into a central intelligence point.

By means of automatic computers (data handlers) this information will be correlated and digested to give the field commander a single presentation on the status of the battle area From this same central point, the field commander will be able to exercise control over aircraft at his disposal

The broad objective of the program is to obtain greater centralization of battle intelligence in less time with more automaticity Dunn doesn't expect the TAC system to have as much automaticity and consequent com

plexity as the air defense system under development by AFCRC and Project Lincoln

▶ **Mobility the Keystone**—For one thing, the keystone of the TAC system must be mobility, giving it freedom to move with the fluid battle area. The stationary, U S based air defense system can set up equipment in duplicate or triplicate in the event that complex primary equipment fails. However the mobile TAC system won't be able to afford this luxury and so must forego unnecessary automaticity

Secondly, the air defense system can have a permanently based well-trained set of specialists, test equipment and spare parts always available for maintenance, whereas maintenance and supply are much more difficult in forward combat areas where TAC must operate

Because of the similarity of portions of the ADC and TAC missions, RADC will be able to use some of the ADC sub system equipments, although in some cases these must be repackaged for vehicular use. Dunn cites a particular type of computer, now going into production, which, with minor design compromise, was made suitable for both the TAC and ADC weapons systems.

▶ **Within the TAC Lab**—The TAC lab is divided into three sections. One, called Systems Analysis, works closely with TAC to determine its operating needs and requirements. For example, how many targets must the system be capable of handling? How big an area of interdiction must the system be capable of covering? If TAC asks for the impossible, or states requirements beyond the present state of the art, the Systems Analysis section must negotiate a satisfactory compromise with TAC on its requirements

▶ **Implementation**—When this has been

RADC's 1,200-ft. antenna is used in long range navigation system studies.

done, the Analysis section draws up a system specification and turns it over to the Systems Implementation section. This group is charged with guidance of the Equipment Development Division to bring needed development along at the proper pace so that all sub systems will be available when they are needed

If certain new airborne equipment is needed for the system, the Implementation section engineers see to it that Wright Air Development Center launches the needed development and then coordinates WADC and RADC efforts

▶ **"Green Box" Group**—If special "green boxes" are needed for the system, the third lab section—System Integration and Evaluation—initiates the necessary development, either within RADC or by outside contractor

When portions of the super system are developed, this same section tests and evaluates their performance, to see how closely they meet the system specifications.

During the course of the program the Analysis section is continuously working with TAC, revising specs where necessary to meet new found TAC needs, or modifying the specs when new developments in the art make improvements possible

▶ **Inside the SAC & MATS Lab**—Overall weapons system responsibility for SAC is assigned to WADC, which in turn subcontracts the long range communications and navigation and some IFF problems to RADC's SAC and MATS lab. MATS work is thrown into the same "hopper" because its long range communication and navigation problems are somewhat akin to those of SAC

The most interesting system project in this laboratory (at least the most interesting one about which RADC is willing to talk) is the automatic traffic control and landing system with its return to base computer. This system has application to all of the AF's operating commands despite the fact it is assigned to this lab

▶ **Getting Them Home**—The return to base phase of military jet operations is called one of the "most critical" by I J Gabelman, chief of the SAC and MATS lab. Military jets can be expected to return to base with little fuel in their tanks and many may have suffered battle damage.

Because jet fuel consumption runs $2\frac{1}{2}$ to 3 times greater at sea level than at high altitudes, jets must stay at high altitude until ready to land and then make a very rapid descent, approach, and landing. For example, jet fighters descend at the rate of about 4,000 ft./min., jet bombers at about 2,500 ft./min

▶**Deft Traffic Control Needed**—Traffic control for military jets must be efficient, speedy, and certain. If a jet fighter or bomber misses his first approach, he may not have enough fuel left to make a second attempt. Approach and landing must be speedy so that an entire flight can be landed before the last-in-line planes run out of fuel. Gabelman says RADC is shooting for a landing rate of two aircraft per minute per runway.

The problem can be viewed this way. Every 30 seconds a "slot" becomes available for landing an airplane. Unless an airplane is ready to fill that landing slot, it is gone and lost forever, and the penalty may be the loss of one or more aircraft that run out of fuel.

RADC believes the solution must be an automatic computer which continuously can take into account the many variables involved and program a close-order approach of dozens of aircraft without danger of collision.

RADC expects to have a single channel experimental return-to-base computer ready for flight test this fall and plans to award a contract for a multi-channel unit during the present fiscal year. Gabelman hopes to be able to demonstrate this unit by early 1955.

▶**How It Works**—Ground-based radars will provide the computer with information on the position, speed, heading, altitude, and identity of every aircraft approaching within "X" mi. of an airdrome.

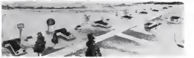
As soon as the plane enters this area, the computer will determine instantly the plane's earliest possible time of arrival at the CCA Gate (start of the final approach path.) The computer will then scan its memory for the first vacant landing slot which will be assigned to the aircraft.

▶**New Heading**—The assigned landing slot might be 30 sec. later than the earliest possible time of airplane arrival, in which case the computer calculates a new flight path heading which will bring the airplane to the CCA gate at the desired time. The new heading can be transmitted by radio to the plane's flight crew, and this is what will be done in the early phases of the program.

The next step is to make the system more foolproof by giving the ground station control of the airplane's flight path via a radio data link whose signals control the plane through its automatic pilot.

▶**Continuous Monitoring**—The return-to-base computer will monitor continuously the position of all aircraft and may, on occasion, have to revamp the previously assigned schedule of arrival because of unforseen events. Human operators on the ground will be able to cause the computer to give special landing priority to disabled aircraft, when so notified by the plane's crew.

RADC hasn't been able to dream up a way to detect battle damage automatically yet.



TACTICAL AIR COMMAND weapons systems and electronic counter measures will be tested at this new RADC site near Verona, N. Y.

Asked whether the return-to-base computer would be the analog or digital type, Gabelman replied that it would be either pure analog, or a mixture of the two, but not pure digital. "We can't afford any down time," Gabelman said, voicing a frequently heard complaint about the present state of digital computer reliability.

▶**Automatic Approach and Landing**—RADC has one portion of its super traffic control system already "under its belt." This is automatic GCA, an expanded version of ground-controlled approach radar which permits an automatic approach via the airplane's autopilot approach coupler and simultaneously gives the pilot ILS-type steering information in the cockpit.

Gilfillan Bros., Inc., is currently going into pilot production on ACCA, following several years of test. ACCA is capable of handling simultaneously up to six aircraft in final approach.

▶**Flare-Out and Landing**—The third portion of the system under investigation at RADC is an automatic flare-out and landing system. An extremely high-frequency ground-based radar will be used to determine the plane's height above ground (to an expected accuracy of two feet) and this information will be transmitted to a small flare-out computer in the airplane.

This device will operate through the autopilot to bring the aircraft in for its landing. Because of its intimate relationship to other parts of the system, the airborne flare-out computer is considered a "green box" and is therefore under development by the SAC and MATS lab.

The SAC and MATS Lab, like the TAC Lab, is divided into three sections, each with responsibilities similar to their TAC counterparts. These sections are: Analysis, Implementation, and Planning & Requirements.

▶**Air Defense Lab**—RADC is a major subcontractor to AFCRC and Project Lincoln in the area of air defense. Systems supervision and guidance of this work is concentrated in the Air Defense Laboratory under J. Walsh. The five sections of the laboratory include: Weapons Systems, Data Processing, Data Handling, Systems Test,

AUTOMATIC GCA can provide automatic approaches through the autopilot in addition to giving pilot normal GCA talk-down.

and Operational Equipment Improvement The latter section reflects the current philosophy of Project Lincoln and AFCRC to use existing equipment wherever possible

Equipment Development

Largest of the four R & D divisions at RADC is Equipment Development which is responsible for bringing through new and/or improved radar, communications, data handling, direction finder, and navigation equipment projects.

Most of the developments are performed by outside contractors The division numbers approximately 300 people, including 100 engineers, and is divided into two laboratories, identified simply as "No 1" and "No 2."

Lab No 1 is essentially a radar/microwave group and Lab No 2 is largely devoted to lower-frequency communications and navigation, according to Allan A Kunze division chief, who has spent more than 10 years in RADC and predecessor Signal Corps labs However, there are enough exceptions to these broad definitions of lab responsibility that RADC decided it would be better to identify the labs by nonrestrictive and undescriptive numbers rather than by names.

Alan A Kunze
Chief, Equipment Development Div

A list of only a few of the Equipment Development Division's current or recently completed projects includes

- **Communication zone indicator.** A device for determining the best frequency to use for communications under existing atmospheric conditions
- **Precision long-range navigation.** Systems for use in missile guidance or determining the point of bomb release from a piloted aircraft
- **Speech compressor.** A system designed to squeeze more useable channels into the crowded radio frequency spectrum by compressing the required bandwidth from ±3,000 cps to a mere 100 cps
- **Data link** A narrow-bandwidth radio telemetering technique designed to transmit steering and guidance information to individual aircraft for display in the cockpit or for controlling the airplane's flight path through its automatic pilot
- **More secure IFF** A much improved system to enable ground radars to identify aircraft as friend or foe with greater assurance that the enemy has not broken the IFF system code.
- **Multi-runway GCA** A new technique for mounting GCA on a turntable which can be rotated to allow a single GCA to cover instrument approaches from either direction and on more than one runway

▶**Lab No. 1 Activities**—Knowledge of what the enemy is doing is the key to military strategy. In aerial warfare, radar is the most important source of such military intelligence This explains why so much RADC effort is going into ground-base radar developments, according to Ernest Storrs, chief of Lab No 1, which guides developments in this field

This lab is divided into four sections-

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Radar Search & Height Finding (Surveillance), Guidance, Beacons, and Terminal Area

Although there has been considerable improvement in radar precision and range since World War II, Storrs says that there is a continuous program for further improvement.

Current work is directed toward higher powers for greater range and improved MTI (moving target indicator) techniques to discriminate better between time targets and ground or atmospheric clutter. Another objective is to improve equipment reliability through better components and by cutting the numbers of tubes required.

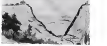
▶ **Step-by-Step Process**—Radar improvement is essentially a slow step-by-step process which must await the development of more powerful magnetrons, more sensitive receiver circuit designs, higher-gain antenna designs and the like, says John Cruickshank, head of the Radar Search and Height Finding Section.

The TAC weapons system program has raised new problems. Radars and their associated operators and maintenance shelters and power supplies must be repackaged for mobile front line use and redesigned to withstand its rigors.

Cruickshank likes the new Systems Division role of giving guidance on the tactical requirements for new equipment. In the earlier postwar days, he says, there was too little tactical usage information available for engineers charged with drawing up equipment specs.

▶ **Big Business**—The size and complexity of ground based surveillance radars usually limits their development to a few of the larger companies. A single surveillance radar may cost up to $1.5 million, and a recent production contract amounted to $50 million, Cruickshank says. Major ground based radar suppliers are General Electric and Bendix Radio Division of Bendix Aviation. Other principal suppliers include RCA, Westinghouse, Crosley, and Hazeltine.

Military security prevented Storrs from saying much about the activities of the Guidance Section of Lab No 1, except that the precision being sought for missile guidance is higher than



RADC test site for radar antennas

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RADC has yet achieved Storrs points out that a radar system used in missile guidance could also be used in tactical bombing to determine the point where bombs should be released

▶ **Radar Beacons Improved**—The IFF system now in use is "far superior to that used in World War II" from a security standpoint, Storrs says (The present airborne and ground based IFF equipment were developed under RADC sponsorship but WADC has the responsibility for packaging the airborne unit to its own requirements)

▶ **World War II Models**—The IFF hurriedly developed during World War II had only four different codes, Storrs says.

The Germans were able to get details on our IFF design from aircraft shot down over occupied Europe and duplicate it for their own aircraft. Then they had only to determine the "code of the night" by monitoring our aircraft, and they could notify German intruder aircraft to set their U S-copied IFF beacons to give a "friendly" response to our allied radar interrogations

▶ **Better Beacons**—Ground-based radar beacons, used for bombing and navigation landmarks by radar-equipped aircraft, have been reduced to about one-quarter of their World War II size, as a result of miniaturization techniques, Storrs says In addition, these beacons now operate at higher peak powers giving longer range operation.

Possibly the most important improvement, however, is in increased beacon reliability

▶ **Terminal Area Aids**—The Civil Aeronautics Administration's air surveillance radars (ASR) and precision approach radars (PAR), which have done so much to improve traffic control and instrument approaches at our larger civil airports, are adaptations of similar radars first developed by RADC and its predecessor, Watson Labs, according to Storrs

Another RADC development, airport Surface Detection Equipment (ASDE), a high-frequency radar used at night and during bad weather at large airports to "see" taxiing aircraft on runways and taxiways, evoked very favorable comment during a year's trial at the large N. Y. International Airport (AVIATION WEEK Sept. 29, 1952, p. 87).

These and similar airport aids are developed under the guidance of the Terminal Aids Section, headed by D. E Waxler One recent development, disclosed here for the first time, may also hold considerable promise for civil air operations.

▶ **Multi-Runway Type GCA**—Permanent GCA installations normally are sited and aligned for conventional upwind landings based on the prevailing wind direction which most frequently exists under instrument weather conditions A sudden reversal or change in wind direction under these conditions either requires a more hazardous downwind landing or results in landing delays.

Mounting GCAs in mobile trailers is not a satisfactory solution to this problem because of the time and trouble involved in moving and realigning them

RADC's solution is a large turntable which mounts and can rotate an AN/FPN 16 precision approach radar through 360 deg (in its production version) in a little over 3 minutes, making the instrument runway usable from either direction. For many airports, the turntable can be sited so that it serves additional runways, making them all instrument runways

The device, built by Craig Machine, Inc., of Danvers, Mass , is calibrated when installed to accurately align itself to any serviceable runway at the push of an appropriate button The original development model is presently installed at Griffiss AFB in Rome and production versions are currently going in at the important military air bases

▶ **B-29 or F-86?**—If ground based radar engineers had their way, they'd hang propellers on jet fighters, because props present a large effective surface to bounce radar energy back to its source, compared to the small frontal reflecting area of the jet fighter airframe and wings.

Since airframe manufacturers would take a dim view of such an addition to their sleek airframes, RADC has had to come up with other fixes The problem is aggravated for PARs which operate at three centimeters (wavelength) because at that wavelength radar energy is seriously attenuated under conditions of moderate rainfall

The Terminal Area Section has devised a gadget which makes an F 86 jet fighter show up as well as a B 29 on a PAR radar scope, Waxler says and it adds only one pound to the weight of the fighter.

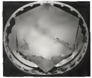
▶ **Corner Reflector**—The gadget is a small "corner reflector" which is attached to the airplane in such a way that it is extended during the final approach but retracted at all other times so as to present no aerodynamic drag and so that it won't serve as a target for enemy radars

A corner reflector consisting of three mutually perpendicular intersecting metal plates, beams back all radar energy striking it within an angle of 40 deg., thereby creating the effect of a much larger target

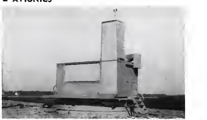
Waxler admits that aircraft manufacturers were skeptical of the idea at first, but he says that they now are giving excellent cooperation in the production of the reflector

▶ **Large Transports Too?**—RADC is currently trying out a larger corner reflector on a large piston engine MATS transport to see if it will improve radar pickup during heavy rainfall However, Waxler cautions that the sizeable radar echoes from the airplane itself might get out of phase with those from the corner reflector in which event the two would tend to cancel each other, giving a poorer target on the scope than would ordinarily be required without the reflector

If RADC works out a satisfactory



REFLECTOR attached to the airplane makes radar echoes stronger.



LARGE TURNTABLE enables this GCA to be quickly aligned to several runways.

solution, it would be applicable to airliners and CAA PARs which have similar problems during heavy rainfall.

▶ Targets in the Rain—Meanwhile RADC has applied other techniques to improving the target return of all sizes of aircraft during heavy rain. One is the use of quarterwave plates to give PAR radar energy circular polarization instead of its normal horizontal polarization. When this is done, radar echoes from aircraft return in normal fashion, but those from raindrops find it almost impossible to reenter the radar antenna from which they earlier emerged. This greatly reduces rain haze on radar scopes, making the target stand out more prominently.

Circular polarization is being used in AN/CPN-18 surveillance radars and in the CAA's newest ASR-3s, built by Bendix Radio, Waxler says. Another RADC technique for reducing rain clutter is the use of new-design MTIs, applying information theory developed by Wiener of MIT and Shannon of Bell Telephone Labs.

▶ Automatic GCA—Automatic GCA, first constructed after the war in Watson Labs, according to Storrs, consists of a conventional PAR (AN/FPN-16) plus a set of tracking computers and accessories. These enable the AGCA to give the pilot an ILS-type cockpit indication and furnish automatic steering signals to the plane's autopilot in addition to the familiar aural talk-down. AGCA, identified in official parlance as GSN-2, can simultaneously handle up to six aircraft in final approach.

The "G" in GSN-2 indicates that the equipment is ground based, the "S" that it is a mixture or combination of radio and radar, and the "N" that the device is used for navigation.

Another RADC conception is the radio direction finder indication presentation on ASR radar scopes, to make it easier to identify individual aircraft.

▶ Scope Indication—As the airplane

NAVAGLOBE, long-distance omnirange-type navigation system, is under RADC test.

transmits over its communications set, a ground based direction finder orients the direction of the broadcast and creates a thin radial line on the radar scope which passes through the airplane's target blip, thereby identifying it

The Terminal Area Section is guiding the development of the very-high-frequency radar which is to be used with RADC's automatic landing system The device must accurately establish the height of an aircraft from the ground during the final phases of landing and flare-out Other section responsibilities include consoles for control towers and radar air traffic control centers

▶ **Making Failure Pay Off**—People normally don't talk about the developments that turned out to be impractical, but Fred Moskowitz, chief of Lab No 2, freely brings up one that failed badly to meet its original, but undisclosed, objectives—and turned out to have very important uses which no one had conceived of at the time the development was launched

Somebody recognized that the sporadic and unpredictable signal return from the skywave could provide vitally important information If there was heavy skywave signal return at some particular range and operating frequency, that meant radio energy (skywave) was getting through under existing atmospheric conditions to that distant point, little or no return—the signal was not getting through This phenomenon could be used to determine the optimum frequency to use in radio communications

So the device was renamed COZI (communications zone indicator) and designed to permit rapid switching of its operating frequency over the band If, for example, an operator wants to find the best frequency for use in radio communications with England, the antenna is pointed in that direction and its elevation angle adjusted until the range or distance of the ground clutter echo corresponds to the distance to England (corrected, of course, for the geometry of the problem) Then the transmitter frequency is varied until the maximum returning signal is obtained—and that is the optimum communication frequency at that time

▶ **Lab No 2 Activities**—Most of the efforts of the 42 civilian engineers assigned to Lab No 2 are spent in guiding outside developments and assisting the AMC in production liaison, Moskowitz reports Only 10% of lab efforts go into in house development The laboratory is divided into the following four sections

- DF & Data Transmission
- Radio Communications Equipment.
- Long Distance Navigation
- Special Devices.

▶ **Versatile DF**—One product of the DF & Data Transmission Section is the AN/CRD 6, a complete UHF direction finding station capable of working more than six aircraft simultaneously and designed for remote operation The station can be remotely tuned to any one of 10 pre-set crystal-controlled channels and can transmit its "findings" by cable up to five miles Another section project is devoted to decreasing the bandwidth requirements for transmitting radar scope presentations from remote radar sites By converting radar intelligence into a pulse code, RADC hopes to trade time for a narrower bandwidth to permit the use of conventional telephone wires for transmission instead of requiring expensive coaxial cable

▶ **Radio Communications**—The Radio Communications Equipment Section of Lab No 2 has responsibility for AF ground based UHF and HF communications gear, although the Signal Corps develops most of the ground based HF equipment used by the three services Wherever Air Force needs are unique, such as in mobile controllers, the work falls to this section

Great progress has been made in unifying the radio communications needs

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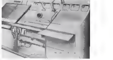
of the three services, particularly in ground based gear, reports Ralph Marks, section chief

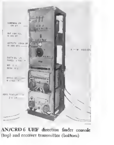
▶ **Exalted Carriers**—RADC is carrying on considerable in house investigation of "exalted carrier" techniques (a dual side-band system in which the carrier is suppressed only when there is no modulation) Advantage of exalted carrier, Marks says, is that it permits a boost in peak power rating without increasing average power rating or consumption, which in turn cuts equipment weight and size. Another by product advantage, Marks says, is that the exalted carrier technique practically eliminates the danger of overmodulation

Marks says that RADC is quite interested in single-side band transmission to give better reception under high noise conditions and to provide more communications channels

The Signal Corps is doing much of the SSB work, Marks says, because SSB finds its greatest application to the HF band However RADC is sponsoring some SSB research at General Electric and Stanford University

▶ **Long-Range Navigation**—One of several long-distance navigation systems





AN/CRD 6 UHF direction finder console (top) and receiver transmitter (bottom)

JEEP MOUNTED mobile radio station has HF and UHF communications

under test by the section of the same name is called Navaglobe. This low frequency 100 150 kc "omnirange," conceived and developed by Federal Telecommunications Lab, has an effective range of 1,500 nautical miles and normally gives a bearing accuracy of one half to one degree

A single station is capable of covering approximately seven million square nautical miles Navaglobe's advantage over loran is that it gives Great Circle bearing directly without reference to charts

The ground station consists of three antennas ("A," "B," and "C") located at the vertices of an equilateral triangle whose sides are 0 36 to 0 4 times the operating wavelength In operation a constant amplitude and constant carrier frequency pulse is transmitted first from antennas "A" and "B," then, after a brief pause, a similar pulse is transmitted from antennas "B" and "C," followed by transmissions from antennas "C" and "A" Finally a synchronizing pulse is transmitted simultaneously by all three antennas The entire cycle takes one second

Because of its relatively low pulse switching rate, Navaglobe gets by with comparatively narrow bandwidth, assuring a good signal-to-noise ratio

An airplane's bearing relative to the Navaglobe station will determine the relative amplitudes of the three signal pulses received (ratio of AB to BC to CA) An airborne receiver compares these pulse magnitudes to establish automatically the plane's bearing relative to the station

A production-designed airborne Navaglobe receiver would be comparable in size and weight to present VHF omnirange receiver, Moskowitz says

▶ **Consolan**—RADC has been working on an improved version of the Sonne system used by the Germans during the war, and the similar Consol system developed by Britain RADC calls its system Consolan Its big advantage, like that of its predecessors is that it requires no special airborne equipment for aircraft carrying a communications receiver and direction finder

RADC's Consolan operates at 193 kc from a two-antenna site has a usable

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signal range of about 3,000 mi and an accuracy of approximately one-half degree, Moskowitz reports This is a 50-100% improvement over World War II performance

▶ **Dots and Dashes**—To use Consolan, the pilot (or navigator) first DFs on the Consolan station to locate himself within a 5 10 degree sector Then he listens to the station, counting the number of dots (short pulses) followed by the number of dashes (long pulses) or vice versa This information is referred to a chart to establish his position within the sector established by DF An alternate method involves the use of a stop watch to time the period during which dots or dashes are heard

Disadvantages of Consolan are the errors introduced by skywaves (or the necessity for additional compensation chart) plus the fact that the system offers the chance for human error Airborne equipment capable of performing these duties automatically could be designed, Moskowitz says, but its weight and complexity would then negate Consolan's basic advantage of simplicity.

This section is also working on several other long-range navigation systems of undisclosed nature

The Long Distance Navigation section is also experimenting with a novel type of long range distance measuring equipment (DME now in use on the civil airways is limited to line-of-sight ranges) If the new DME proves out, it can be used with Navaglobe to provide input signals for offset track (rho theta) computers, Moskowitz says

▶ **Special Devices Section**—As its name suggests, the Special Devices section is a sort of "catchall" for nondescript, but important, Equipment Development Division projects For example, RADC had limited need for CAA-type VHF omnirange stations, but found that the CAA antenna array was too difficult and time-consuming to site and align particularly for mobile use Also, it wanted a broadband antenna which would permit a change in omnirange transmitter frequency without requiring antenna retuning

Under RADC guidance, Federal Telecommunications Lab developed the "caged dipole" antenna which meets AF needs This antenna consists of a small ½ wave dipole which rotates inside a cage, exciting the bars of the cage which in turn radiate the RF energy Original problems with excessive vertical polarization in this antenna have now been solved by means of a small cap on top of the antenna, Moskowitz reports

▶ **Crash Locator System**—A system designed to locate crashed aircraft automatically to permit immediate rescue has been developed jointly by RADC and WADC A small radio beacon (carried in the tail of an airplane) is catapulted out after a crash, and transmits an SOS, a special "crash code" as well as identifying the plane and the elapsed time since its crash A series of ground based stations developed by RADC will monitor the beacon wavelength continuously via an alarm receiver which is "sensitive" to the beacon's code despite high noise levels and low beacon power

When the alarm receiver hears a beacon code, it automatically will turn on a tape recorder to record the beacon signals and a direction finder which takes a bearing on the crash beacon This bearing is then converted into code and automatically teletyped to a remote plotting board which is also being fed by other crash locator stations From two or more DF bearings, (only two would be needed if the beacon signal is coming through good and strong), the plotter calculates the most probable location of the crashed airplane, and plots a contour indicating the most likely area where the disabled aircraft may be found.

This system, slated for test this summer, is an interesting example of intercenter cooperation WADC and RADC work together through a steering committee and there has been no need to assign overall system responsibility to

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the one center, Allan Kunze reports.

▶ Speech Compressor—Another Special Devices project is a speech compression system to convert speech into a pulse code in order to transmit it over a 100-cps bandwidth instead of the usual 3,000-cps bandwidth Similar techniques are employed to transmit radar scope presentations over a narrower bandwidth.

Kunze reports that the receiving end of the speech compressor is working at present and the transmitter is under way One of the major problems is to reduce the present large equipment size, Kunze says

▶ Data Link—RADC is currently flight testing a data link system for transmission of guidance and navigation instructions via the communications receiver, without disrupting normal voice communications

The object is to permit automatic control from ground stations and to relieve the voice channels as much as possible The RADC system requires only an adapter to existing communications receiver to sort out steering signals for presentation on cockpit instruments or for transmission to the plane's automatic pilot

▶ Conversation Interrupter—Anyone who has tried to make an urgent phone call only to get repeated busy signals from a seemingly endless conversation on the other end, will applaud another Special Devices project It is a device which will permit a priority caller to interrupt a telephone conversation in an emergency and cut out the unwanted party

Electronic Warfare And Techniques

Electronic warfare, sometimes called electronic counter-measures, is a new domain of warfare which substitutes electromagnetic radiation for the bul

CAGED DIPOLE omnirange antenna.

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lets, bombs and shells of conventional warfare.

▶ **New Coordinates**—Instead of being fought in the familiar battle coordinates of space, electronic warfare is fought in the coordinates of frequency and time.

Responsibility for developing equipment to permit the Air Force to wage electronic warfare from the ground, and for investigating new techniques for application to this and other fields of RADC activity, falls to the Electronic Warfare & Techniques Division.

The division, headed by R. O. Schlegelmilch (also a veteran of 10 years in RADC and predecessor labs), is staffed by approximately 140 persons, of whom about half are engineers and scientists.

Manpower is almost equally divided between the division's two laboratories: Electronic Warfare, under Joseph Vogelman, and Research and Applied Techniques, headed by Morris Handelsman. Both labs, and particularly the Research and Applied Techniques group, do more in-house development than other RADC labs.

▶ **Fighting With Radiation**—Electronic warfare may be divided into two forms, both closely related:

- **Active.** Influencing, disrupting or deceiving enemy electromagnetic transmissions by active countermeasures (such as jamming).
- **Passive.** Intercepting enemy electromagnetic radiations to learn his future battle plans and/or to determine enemy techniques and operating frequencies for use in developing our active countermeasures.

▶ **"Fire Fighting"**—Most of the countermeasures used during World War II were developed to meet specific needs and not as a part of a coordinated system of electronic warfare, according to Richard Libby, chief of the lab's Detection and Evaluation section. It was usually a case of "fire fighting"—putting out individual blazes," is the way Libby describes it. RADC is directing its current work toward more overall integration of electronic warfare techniques.

Postwar interrogation of former enemy military and scientific personnel has produced conflicting testimony as to the effectiveness of such World War II countermeasures as our use of chaff—large quantities of metal foil ribbons dropped from aircraft, which slowly flutter to earth creating a large radar echo on ground radars, aimed at masking intruding bombers.

▶ **Great Unknown**—One of RADC's tasks is to develop techniques to prevent our ground radars from being fooled by enemy-dropped chaff, but this is only a small part of the problem.

Enemy bombers may carry devices to generate electromagnetic radiation to jam our ground radars and communications. Equally important, we want to jam their bombing radars to make them ineffective. This lab must be able to counteract enemy radiation through the entire electromagnetic spectrum, "from d.c. to the frequency of light," is the way Libby expresses it.

Deception is another in EW's bag of tricks. One technique reportedly used by the Reds in Korea is to set up a radio beacon operating on the same frequency as those which we set up near airbases for homing purposes. An unwary U.N. pilot is apt to home on the enemy beacon and fly into a mountain top.

▶ **In Readiness**—Uncertainty on what avionics equipment or countermeasures an enemy may throw at us poses an obvious problem to the EW lab. The lab recognizes that it would be far too expensive to build up vast quantities of equipment to combat anticipated enemy equipment that might never be used against us. Yet they recognize that it takes five to six years to research, develop, design and get new equipment into production.

For this reason RADC spends its limited EW resources mostly on research and development. The idea is to have a large number of equipments completely designed and ready for production, when and if needed. Actual production time is then only a matter of months. Operating on this philosophy, RADC is building up a reservoir of electronic warfare knowledge in industry, universities, and the Air Force, to enable it to counter the unexpected.

▶ **Seek the Weak Link**—Engineers designing EW equipment need a strong background in a variety of equipment techniques, to enable them to seek out the most vulnerable spot in the equipment they seek to counteract or jam. They must also consider the economics of the problem and employ techniques which will be least expensive to manufacture.

Not knowing what the enemy might use, the engineer must make a realistic appraisal of the probability of an enemy using or not using certain types of avionic equipment.

▶ **We vs. Us**—Lacking knowledge of enemy capabilities, there is a tendency for us to design our EW equipment to "fight" our own airborne equipment, Libby says. This is a healthy situation because it pits all the ingenuity of our airborne equipment designers against our ground-based electronic warfare designers.

When, for example, tests show that RADC developed techniques will jam WADC-developed bombing radar, WADC engineers are spurred to greater efforts on "jam proofing." Similarly if WADC develops a "jam proof" air-

borne bombing radar RADC engineers must develop new techniques

▶ **EW Lab Operation**—When a military requirement for new EW capabilities arrives in the lab, it is evaluated by the Integration & Analysis section to establish the technical requirements From here the program moves to the Detection & Evaluation section and the Countermeasures & Deception section

These groups sponsor the development of experimental equipment, either within RADC or by contractors, to establish the EW techniques needed

The Production Development section is responsible for guiding the development of prototype equipment by industrial contractors, and for building up industrial interest and potential in EW Evaluation of this prototype equipment for tactical suitability is accomplished by the Engineering & Operational Evaluation section

As an additional objective the EW lab is trying to establish itself as a place where industry engineers designing avionic equipment can come for consultation on the latest anti jamming techniques

▶ **Research & Applied Techniques**—Approximately half of the efforts of the Research & Applied Techniques lab are devoted to developing components and techniques which will find use in ground-based avionics five to 10 years from now, the other half is devoted to solving RADC's current problems and meeting its current needs

Prior to the January reorganization, the R&AT Lab was part of the Radar lab, which explains why much of its current work is in the field of radar and microwaves However the lab is fast expanding its activities into the lower

R O Schlegemilch, Chief Electronic Warfare & Techniques

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frequency regions and into the new fields of transistors and ferrites, according to Morris Handelsman, chief of this lab

▶ **Study Is Cheap**—Analysis and study are comparatively cheap, Handelsman says That is why he encourages his group to do as much analytical and study work as possible to prove out fundamentals before letting contracts for the development of hardware Approximately half of the current problem development work is done in the lab, the balance outside

In the field of advanced research, roughly 80% of the work is performed by outside contractors In the past, industry has done the majority of this work, Handelsman says, but such universities as Brooklyn Polytech, Carnegie Tech, Syracuse and Cornell are edging farther into the field

R&AT lab's applied research activities take it into the realm of AF Cambridge Research Center activities so there is considerable coordination between the two to prevent duplication of efforts, Handelsman says

The R&AT Lab is divided into the following four sections

- Radio Frequency
- Receiver & MTI (moving target indicator).
- Circuits
- Echo Area & Propagation.

▶ **Improvements Bring Problems**—The greatly increased power of today's radars, coupled with the use of more sensitive mixer crystals to obtain better signals in the face of extraneous noise, raised the need for improved duplexers—fast-acting electronic switches which alternately connect the transmitter and receiver to the common radar antenna so that high powered transmitter pulses don't swamp the receiver and burn out the mixer crystals

Several years ago, satisfactory duplexers were "a real bind," Handelsman says, but not today, as a result of RADC sponsored developments

▶ **Stable Klystrons**—The RF section also sponsors the development of higher powered klystron tubes as possible replacements for the previously used magnetrons Klystrons look attractive because of their greater frequency stability

Handelsman reports considerable progress in this area, although he declines to say what output powers have been achieved

Another area of great improvement is in antenna rotary joints These have gotten increasingly complex with the use of additional antenna feeds, but new rotary joints with excellent characteristics have been developed, Handelsman says

▶ **High-Power Radar Lab**—The R&AT lab is quite proud of its new high-power radar lab, a research facility which can generate very large amounts of microwave power at any desired frequency. Just how much power this lab can generate was not disclosed for security reasons.

The lab, which is available to military contractors for testing high power duplexers, rotary joints, klystrons, dummy loads, and the like, was constructed on a shoestring budget, largely from components scavenged from old obsolete radar sets, Handelsman says

▶ **"Cloak & Dagger" Antennas**—The RF section's work includes antennas for radar, navigation, communications, electronic warfare, and what Handelsman obliquely refers to as "cloak and dagger" applications

In radar antennas, this section has sponsored an outside development which will permit the use of very rapid antenna scan rates and very narrow beam widths, an ideal combination for precision radars

▶ **Wanted: An Easy Formula**—A development and study program designed to save the government money and save its radar contractors many headaches is under way at Syracuse University

The program is aimed at this problem When mechanical tolerances are not held sufficiently close in the manufacture of large radar antennas, the beam shape is distorted, if held to theoretically desirable values, the fabrication of these antennas becomes an extremely expensive and exasperating job, Handelsman says

What RADC wants is an easy-to-use formula which will allow mechanical designers to predict in advance the over-all effect of minor variations in various parts of the antenna This should enable the antenna designers to establish acceptable mechanical fabrication tolerances.

ENVIRONMENT TEST chambers at RADC will be large enough to hold a truck.

Syracuse University has already completed part of the program The relationship between electrical phase relationship of the radar energy and the antenna beam shape Now it is working back to correlate this phase relationship and minor deviations in antenna configuration. End product is expected to be a design handbook for radar antenna engineers

Other work in this group includes development of broad-band communications antennas to ease tuning problems and studies of the effect of radar feed horn defocusing in parabolic antennas

▶ **Target Discriminators**—As a result of RADC-sponsored developments, the moving target indicators (MIT) used in present radars are much better able to discriminate between real targets and spurious clutter than were World War II radars, Handelsman says

This is partially attributable to improved circuitry, and partly to new devices like the quartz delay line which replaces the older mercury delay lines. Advantage of the quartz lines is that they are much smaller, lighter, and only one third as sensitive to temperature change as mercury delay lines, Handelsman says

▶ **Reducing Cross Interference**—The Receiver & MTI section has developed circuitry called "video blankers" which reduce the cross interference from two or more radars, operating in close proximity

Another in-house development of which Handelsman is proud is a simplified technique for measuring incremental pulse time jitter to within 0.002 microseconds This jitter is the short period variation in the firing time of hydrogen thyratron tubes used as modulators in MTI-equipped radars

▶ **Position Prediction**—One interesting development of the circuits section is a velocity-tracking circuit for GCA designed to give stronger target signals in the presence of much spurious noise

The device is a combination memory and predictor Based on the past velocity of the airplane (target) being tracked, and its last position, the velocity tracking circuit in effect predicts approximately where the plane will be during the next scan and then attenuates signals from outside the area of this predicted position

▶ **Investigating New Materials**—New devices and materials, such as transistors and ferrites, are also under exploration here. There are several programs under way to experimentally transistorize existing vacuum-tube devices

Another outside program is pointed

■ AVIONICS

toward the use of ferrites to control the plane of polarization of microwave energy. The major problem here, Handelsman says, is to find techniques to enable ferrites to handle the very large powers involved. The use of ferrites for magnetic modulators and digital computer work is also under investigation

This section also does advanced thinking on data handling, data gathering, and computer memory systems to determine what components will be needed five to 10 years hence

▶ **Predicting Radar Range**—The Echo & Propagation section has developed an empirical technique which makes it possible to predict the range and performance of new pulse-type radars while they are still in the paper design stages. Handelsman reports that accuracy of prediction usually runs better than 15%.

The technique is based on an extensive analysis of the performance of a variety of existing radars against different size targets, to establish the performance of a "standard radar." From this known standard, the range of a new radar design can be extrapolated, based on the differences between it and the standard radar, Handelsman says.

The technique is applied, for example, to the design of new GCA or GCI radars to determine the optimum frequency and other design parameters based on the performance that will be required for the specific radar application

▶ **Beyond Line of Sight**—Recent investigations have shown that microwaves can be propagated considerably beyond line-of-sight distances, previously considered their practical limit This is particularly attractive for use in microwave communication networks in over-water areas where it isn't always possible to install microwave repeater stations within light-of sight distance of each other

There still remains considerable disagreement among the experts as to how antenna size, operating frequency, and pulse length affect beyond-line-of-sight performance, Handelsman reports. For this reason, RADC is sponsoring a program at Cornell University to investigate the effect of these parameters on long-distance performance. The E & P section is currently building equipment to test out Cornell's conclusions.

Engineering Support

RADC has located all of the technical supporting activities for its three other divisions, and their seven laboratories, in a single division, called the Engineering Support Division RADC labs turn to this division whenever they need

- Environmental test facilities.
- Radio interference reduction know-how.
- Investigation of new materials.
- Preparation of specifications
- Mobile radio stations for flight test activities
- Special instrumentation.

These are but a few of the many services provided by this division

▶ **Support Labs**—The Engineering Support Division is staffed by approximately 270 persons, of which about 25% are engineers, according to O. G. Tallman, division chief Tallman is a 12-year veteran with RADC and the earlier Signal Corps labs from which it was formed The division is broken down into two laboratories and one branch These are

- General Engineering Laboratory.
- Test & Evaluation Laboratory.
- Services Branch.

▶ **Mechanical Engineering**—All mechanical design activities are centered in the Mechanical Engineering section, one of five sections in the General Engineering lab

As originally set up, project engineers in other laboratories were to bring their mechanical design problems to this section Recently it was decided to place a liaison engineer from this section in each of the seven development

laboratories, to live more closely with the problems of that particular lab.

This section has specialists in such fields as shock and vibration, structural concrete (for large antenna and radio towers), antenna mast design, vehicular design, and shelters. Large radar and radio antennas pose major structural problems, Tallman points out, because they must be designed to withstand winds of very high velocity.

The ME section does all drafting for the other labs, and monitors drawing practices used by outside contractors to be sure that they conform to government and AF standards.

▶ **Interference Reduction**—Whenever project engineers encounter radio or radar interference problems, they can bring them to the Interference Reduction section. Ignition interference problems in vehicular equipment have been fairly well solved, Tallman says.

Current work is devoted to basic studies on the character of noise, the sources of radar interference, and its tolerable limits. Some of this study work is being done in the house but much assistance is rendered by Purdue University.

This section is also working on techniques for improving radar modulators, connectors and other components, to eliminate sources of interference between radars operating in close proximity.

In the course of its interference reduction work, this section has developed field intensity measuring equipment, for both the lab and the field, as well as noise generators and calibrators, Tallman says.

▶ **Systems Requirements**—One of the responsibilities of the Systems Requirements section is to determine how much test equipment should be built into ground radars and other avionic equipment for use by line maintenance personnel. This involves a study of the equipment's design and field maintenance practices.

On some very important projects, this section works directly with the equipment manufacturer, Tallman says. On others, it works through the RADC project engineer.

The Systems Requirements section also determines what new types of separate test equipment will be required. Supervision of a contractor's development of such equipment falls to another group, called the Instrumentation Development section. This section also serves as a consultant to other laboratories for specialized lab or flight test instrumentation and maintains a standards and calibration center for RADC instruments.

▶ **New Materials**—Investigations of the properties of new materials which have

■ AVIONICS

application to ground-based avionics are carried out in, or sponsored by, the Materials & Miniaturization section. This includes ceramics, plastics, metals, as well as plating techniques and encapsulating compounds for miniaturized avionic construction.

The objective of this section is to keep abreast of the current state of the art so as to spot potential RADC applications for new materials.

One example of the M&M work is in the use of bi-metals to fabricate radar waveguides, thereby greatly reducing weight and cutting the use of strategic materials. Another example is the high-strength plastic radome covering which is inflated around a large ground radar antenna like a rubber balloon, but is capable of withstanding wind and ice.

Once the initial groundwork is done, development of the new materials is normally contracted out to industry, Tallman says.

▶ Test Equipment Service—To avoid unnecessary duplication of test equipmen in the various RADC labs, the General Engineering lab provides a centralized test equipment supply service for all other labs.

When an individual project engineer needs a specific piece of test equipment, he phones this centralized supply. If the lab has such equipment, and it is in stock, it is delivered to the engineer (and picked up when he's finished).

If the equipment is in use elsewhere, the lab has a record of who has checked it out and can refer the project engineer to that individual.

▶ Services Branch—One of the functions of the Services Branch is to provide mobile radio stations and crews which can be transported to other bases or to a contractor's plant to provide flight test communications facilities. The Radio Communications section of this branch also operates the GAFB radio stations which provide HF, VHF, and UHF communications for flight tests.

In addition, this section coordinates radio frequency allocations and secures any additional ones whenever they are needed.

▶ Spec Uniformity—To achieve uni-

RUBBER BALLOON protects radars.

formity in RADC specifications, they are processed through the Engineering Data section of the Services branch. This same section also:

• **Prepares MIL-type specs** for RADC-developed test equipment used by all three services

• **Checks the contractor-recommended** spare parts list for development equipment

• **Issues authorization** for purchase of new developments

• **Establishes type classification** (development, tentative standard, etc.) which tells tactical commands the status of the equipment from the standpoint of its use in the field

• **Requests assignment** of standard JAN identification for new RADC developed equipment

► **Procurement Data**—The Production Procurement Data section is the focal point between the AMC unit here and RADC engineers engaged in supporting procurement programs.

Equipment specifications prepared by the RADC project engineer are run through this section to put them into accepted and uniform style before transmitting them to AMC

This section, after consultation with RADC project engineers, makes engineering recommendation to the AMC, indicating whether it is feasible to break the procurement down into small contract chunks, whether it is a sole-source item, and whether a negotiated type procurement is desirable from a technical view point

► **Tech Information Group**—All information on foreign technology received by RADC funnels through the Technical Information section where it is evaluated and then disseminated to interested labs. This section also

• **Determines security** classification of all RADC prepared reports

• **Processes progress** reports on all laboratory projects

• **Operates a technical library** and performs reference work

• **Receives all reports** from outside contractors and acts as a repository for USAF and other military reports

RADC tester simulates rough handling

• **Provides editing,** art, and publication services for getting out RADC technical reports

► **Test & Evaluation**—When RADC engineers want to evaluate new materials, test the performance of new equipment, or check its ability to withstand environmental rigors, they turn to the Test & Evaluation lab of the Engineering Support Division

T&E lab personnel will perform these tests for RADC engineers (or RADC contractors) evaluate the material or equipment, and write a final report. Or, if the project engineer desires, the T&E lab will make available its climatic test chambers and facilities for him to conduct his own tests.

Typical T&E lab capabilities include the following types of testing

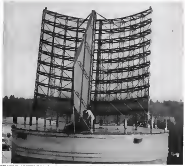
• **Electrical** Life tests, temperature rise, and suitability tests on small components, such as transformers, capacitors, relays, etc

• **Electronic** VSWR of RF transmission lines, phase shift at audio frequencies, servo system performance tests, spurious radiation intensity, analysis of audio frequency output

• **Chemical,** Quantitative and qualitative analysis, quality control of plating solutions

• **Physical** Corrosion, hardness tensile strength, impact fatigue, elongation

• Various **facilities** for mechanical and environmental tests



SINGLE ANTENNA does the job of two gives azimuth, range and height data.

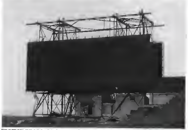
Electronics Research Directorate's Job:

Putting Avionics Research to Work

Cambridge, Mass.—There may be a radical change in spelling in the American language, at least in military and business circles, as a result of studies now under way at the Electronics Research Directorate of the AF Cambridge Research Center here

Within five to 10 years, it should be possible to dictate a message directly to an automatic electric typewriter, via a microphone, and have the machine instantly type out the message with the words spelled phonetically, i e "fonetikly."

This AFCRC research program has far more important military uses than merely to help the harassed military or business man who has trouble getting



PROJECT BILLBOARD is an experimental radar built by Electronics Research.

secretarial help. Nor does the AFCRC have any quarrel with accepted word spelling, inconsistent though it may be.

▶ **Three-Fold Objective**—The fundamental research into speech analysis and synthesis under way at AFCRC is pointed toward:

- **Cramming more information** into narrower radio frequency bands, to create more communications channels in the crowded spectrum.
- **Speeding communication** to allow voice instructions to be instantly converted into printed instructions in one or more distant locations, without the delays and chance for error involved when humans must convert the oral message to hand written notes and then transfer these notes to a teletype machine.
- **More effective cryptography.** By converting the spoken word into a series of pulses necessary to achieve the other objectives, the message can be "scrambled" in a greater variety of ways making it more difficult for an enemy to decipher.

▶ **Microtronics**—Although AFCRC's Electronics Research Directorate (ERD) doesn't scorn present subminiature avionic construction techniques for some current needs, it is researching new techniques which might permit a 100-fold decrease in equipment size compared with that possible with present subminiature techniques.

ERD is aiming at such extremely subminiature techniques that it has coined a new word to describe them: "Microtronics."

ERD's research in microtronics is still in its early stages. If the program pans out, the wristwatch radio transmitter/receiver which Dick Tracy uses in his comic strip adventures would be an easy accomplishment. Even a wristwatch television receiver is not beyond the realm of possibility, although this is not the objective of the work being done by ERD.

▶ **Research Its Mission**—ERD was originally set up as an Air Force applied electronic research center. However it is impractical, if not impossible, to draw a firm line of demarcation between applied research and development, according to Dr. E. G. Schneider, director of ERD.

Broadly stated, avionic equipment developed by Wright and Rome Air Development Centers is usually pointed toward a specific tactical need and is frequently the prototype of production equipment to follow. Until recently, any equipment developed at AFCRC was used primarily to conduct research or to prove out fundamental principles.

ERD's research activities run the gamut from tiny transistors, smaller

Dr. E. G. Schneider, Director Electronics Research Directorate

than the head of a pin, to huge radar antennas, as tall as a four-story building.

One of the characteristics of applied research is that not all the ideas tried prove practical. But since the objective of research is to obtain knowledge, ERD frequently learns as much from "failure" as from "success."

Occasionally researchers discover something early in their investigation which actually proves more interesting than their initial objective. This may deflect the program from its originally intended purpose.

▶ **Important New Role**—Within recent months, ERD has assumed an important new role in the ARDC setup—overall responsibility for "ground environment" (ground-based avionic equipment to be used in the continental air defense system—Project Lincoln). This system is under development in the AF's Lincoln Laboratories, operated by the Massachusetts Institute of Technology in the Boston area.

Unlike RADC and WADC, which of necessity devote a sizable part of their manpower to monitoring developments by outside contractors and supporting AMC procurement, most of ERD's research and development have previously been performed within its own laboratories, Dr. Schneider says.

Dr. Schneider considers lots of in-house work imperative for an activity like AFCRC in order to attract top scientific personnel and to maintain their technical competence.

▶ **Keep It Small**—The Electronics Research Directorate has a staff of approximately 150 scientists and engineers, plus 50 technicians capable of doing engineering work in narrow fields of activity.

Even if budget limitations were not confining, Dr. Schneider wouldn't want to expand ERD much beyond its pres-

ent size. He strongly believes in keeping laboratories relatively small and tightly knit, to avoid intra lab communications problems.

Dr Schneider cites the wartime MIT radiation lab (of which he was a member) which assembled a technical staff of thousands to work on radar, as an example of staff size exceeding the point of diminishing returns

▶ **In the Beginning**—The MIT and Harvard wartime radiation laboratories provided the nucleus from which AFCRC was formed. When the war ended, these laboratories were disbanded Recognizing the need for continuing efforts in the radar field, the Air Force moved quickly to provide facilities for those scientists who wished to continue in the same type of activity—which became the present Cambridge Research Center.

Dr Schneider says ERD has been very successful in hiring needed scientists. He attributes this to ERD's geographic location—near MIT, Harvard, and Boston University—which enables AFCRC men to do advanced study, something close to the hearts of most researchers If this advanced study is directly connected with a scientist's work at AFCRC, the government foots the tuition, Dr Schneider says.

▶ **ERD Organization**—As ERD grew, it found itself trying to carry out applied research, component development and some systems engineering activities within its laboratories. The result was a tendency to divert efforts from research into systems engineering activities, Dr Schneider says The present organizational setup is intended to separate the two types of activities.

The Electronics Research Directorate is divided into two groups, one devoted to components and techniques, and the other to systems From a manpower standpoint, the ERD staff is split approximately 50/50 between the two

▶ **Components and Techniques**—The Components and Techniques group's area of activity is covered by five labs

- **Communications**
- **Propagation**
- **RF components.**
- **Antennas**
- **Computers.**

▶ **Systems Projects**—Project Lincoln is by far the biggest and most important program in the Systems Project Office, headed by M. H Chaffee

AFCRC is also investigating automatic control of traffic around an airdrome along with RADC and WADC

Communicotions

The Communications lab might more aptly be called a "transmission of information lab," according to Dr E W Samson, its chief

It doesn't concern itself with conventional radio or telephone problems, but delves deeply into long haired philosophies and theories behind the transmission of information Its research activities are pointed toward an automatic typewriter which operates from the spoken word, a very advanced type of IFF system (identification, friend or foe), and microtronic techniques, which are necessary if the former equipment is to be small and light enough to carry in an airplane

The Communications lab is divided into four sections

- **Speech**
- **Analysis (largely IFF)**
- **Microtronics**
- **Circuitry.**

▶ **Speeding Flow of Information**—If World War III should come, the life of the nation may depend upon split-second decisions and split-second transmission of these decisions and commands to aircraft and air defense centers

All the efforts now going into complex systems designed to funnel data on enemy aircraft into central control points will be for nought if it takes 5-10 minutes to transmit tactical decisions to their many destinations, or if aural transmission causes the message to be misunderstood

This points up the importance and

usefulness of a system in which vocal commands could be instantly converted into the kind of electric signals which can operate an electric typewriter in order to convert human speech directly into printed messages. This involves the conversion of the complex speech waveform (with its varying intensities and frequencies) into groups of individual pulses—the type of signal from which an electric typewriter can operate.

Research on such system is under way in the Speech section of the Communications Lab.

► **It's Not Easy**—The problem is a tough one because of the wide variations in speech characteristics between individuals. The system must be capable of operating whether the man at the mike speaks with a Southern drawl, a New England twang, or speaks "Brooklynese."

There are a variety of ways to produce speech code patterns, Dr. Samson says, but the lab is digging deeply into fundamentals to find a sound basis upon which to build its system. This involves finding those speech characteristics which are unique to a specific word (or bit of information) and which are common to the word regardless of the individual speaking it.

Considerable effort during the past several years has gone into the study and design of an "audio speech spectograph"—device to analyze human speech. This device will soon be ready for use and Dr. Samson expects to obtain much significant data during the coming year.

► **Pulse Coding Advantages**—There are several important by-product advantages to converting speech into coded pulses. One is that it can compress individual communication channel bandwidth from its present 3,000 cps requirement to a mere 300 cps, and possibly even as low as 100 cps.

That means that 10-30 times as many communication channels can be squeezed into a spectrum now providing only one channel.

Dr. Samson believes that bandwidth requirements could be reduced below 100 cps. if the system were designed to eliminate unnecessary letters from words—what he calls "redundancy within a word." For example, the word "repeat" might be cut down to "rpet."

However this type of "shorthand" could cause some confusion in interpretation. The lab is not working toward this degree of bandwidth compression at present, Dr. Samson says.

► **"Scrambling" Aid**—Another important advantage of coded pulse communication is that it allows a very large variety of "scrambling" techniques to

prevent an enemy from deciphering its meaning

Pulse coding requires extremely high-Q (very selective) filters and the lab is doing considerable work in this field, including both piano-wire type filters and the use of transistors as active-element filters, Dr Samson says.

▶ **Better Reliability Needed**—Coded pulse communications will force us to improve the reliability of radio transmissions, Dr Samson believes

In voice communications, failure to hear an occasional word or syllable, due to interference or fading, normally doesn't prevent understanding the message For example, if a wife calls in to her husband "John, dinner is on the table" just as a truck rumbles by, he may only hear "ner z on the able," yet he'll probably grasp its full meaning

If one or two pulses in a group are obliterated by interference at frequent intervals, the entire transmission may be garbled beyond understandability "Unless we can largely eliminate fading and interference in pulse code transmissions," Dr Samson says, "we may have to introduce redundancy in our transmissions"

The Communications lab first got into pulse coding activities when it was given the problem of reducing the bandwidth needed to transmit a radar scope presentation to a remote location. The lab developed a pulse transformation process which cut bandwidth requirements from the original one megacycle to only several kilocycles, Dr Samson says

▶ **Digitizing & Microtronics**—There is a growing interest and activity in the field of applying digital computer techniques to certain airborne equipments. However these digital techniques involve the use of many complex matrices, each made up of hundreds or thousands of diodes, transistors, and associated wiring and components

What is needed is a brand new microscopic type of construction and such a program has been launched in the Microtronics section

▶ **Transistors Too Big**—Although transistors are small compared to vacuum tubes, the germanium crystal, which is really the heart of the device, occupies only a tiny portion of the volume The leads, supports, case, and other associated paraphernalia, add the bulk

To eliminate this "waste" volume, the Microtronics section is working on a process to build up large numbers of tiny transistors and diodes by depositing successive layers of germanium (and impurities) on a small postage-stamp sized card which has razor-thin interconnecting conductors engraved or printed on it

By stacking these cards in sandwich style, a matrix consisting of as many as 1,000 transistors, diodes and associated wiring and components may be constructed to occupy a volume of only one half a cubic inch

▶ **Outside Help**—These microscopic matrices need equally tiny resistors, capacitors and other components AFCRC has launched a research program at the Mellon Memorial Research Institute and Battelle Research Institute to develop microtronic techniques for making these components

Inductors may be the most difficult to "microtronicize," Dr Samson says, and so thought is being given to using other circuit elements to achieve phase shift eliminating the need for inductors

▶ **Solid-State Physics**—AFCRC has built up its technical knowledge in the field of solid-state physics to carry out its work in microtronics, but there is also another reason

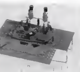
When new transistor developments or techniques are announced by Bell Telephone Lab or others engaged in transistor development, it normally requires a year or more before the new product is commercially available

By having its own capabilities in this field, AFCRC scientists are able immediately to fabricate a new-type transistor

in their own laboratories

With a basic understanding of solid-state physics, AFCRC is also able to develop transistor circuit techniques which overcome certain shortcomings of the devices.

For example, the Circuitry section of the Communications lab has developed techniques for overcoming the transistor "hole" storage time, making it possible to design a computer shift register which can operate at frequencies as high as 9 mc



TRANSISTOR flip-flop circuit can operate at frequencies of 9 mc.

Another product of AFCRC work in the field is an experimental negative-resistance germanium diode which can replace two vacuum tubes normally required in simple flip flop circuits.

▶ **Facilities**—AFCRC has facilities for refining experimental quantities of germanium and producing point contact transistors. To measure the structure, chemical composition, and cell size and orientation of transistor materials, the Microtronics section has an electron microscope, optical grating spectograph, and Geiger-counter X Ray spectograph.

Investigations planned for the future include silicon (high temperature) transistors, non-linear dielectrics such as barium titanate, and ferrites

Application of commercially available transistors and experimental ones developed in the Microtronics section is made in the Circuitry section The 9 mc shift register is their project

Another is a classified airborne digital device slated for flight tests next year

Propagation Lab

The Propagation laboratory, formed about a year ago, is principally concerned with tropospheric propagation (line of sight), although it has some interest in ionospheric propagation. Small in size, this laboratory's mission is to "try to understand rather than to design things," according to Dr. Philip Newman, lab chief

One current lab investigation is in the field of beyond line-of-sight transmission of microwaves It was previously thought that the field strength of microwaves fell off exponentially beyond the horizons, requiring tremendous boosts in power to achieve tiny increases in range.

Recent data obtained here indicates that after an initial 40-db attenuation beyond the horizon, field strength attenuates much more slowly with increased distances This phenomenon may be due to scattering or refraction due to moisture or to temperature differences, Dr Newman says

▶ **MW Communications**—This new knowledge should prove extremely useful in microwave communication networks When these are constructed over water or wild terrain, it is not always convenient to locate repeater stations within line-of-sight distance of one another If greater range can be obtained without huge increases in power, this problem is greatly eased

The technique is not applicable to radar where the echo signal is too small to make the return trip beyond line-of-sight distances

▶ **Other Activities**—Approximately 30-40% of the Propagation lab's 10-man professional scientific staff is currently exploiting what T F Rogers, assistant lab chief, calls a "technological breakthrough" for a classified program (A "technological breakthrough" is a term used to describe a fortuitous technological discovery which holds great promise for solving a pressing military problem)

This lab is also experimenting with COZI—the Communications Zone Indicator—developed initially by RADC, as a long range radar but which is more useful in determining the amount of power reaching a remote location and the optimum transmitting frequency to use

▶ **Propagation Characteristics**—Other activities include investigation of the propagation characteristics of ultra-microwaves—whose wavelength approaches the infra-red region

In its research, the Propagation lab works closely with scientists in AFCRC's Geophysics labs, because of the interrelation of atmospheric conditions and disturbances on the propagation of electromagnetic radiation

In the past there was a tendency for communications and radar equipment designers to overlook propagation and atmospheric effects, Dr. Newman says As an example, he cites the choice of the 1 25-cm (K band) wavelength for radar during the last war

This wavelength was almost the worst possible choice, because attenuation of radar signals by moisture and rain is a maximum at that particular wavelength, Dr Newman points out

The Propagation laboratory has been

delegated prime responsibility in this area by the Air Force, and it serves as a consultant to other ARDC centers, operating commands, and industry.

RF Components Lab

The ideas for new experimental ground-based radars and many of the components needed to build them are developed in the RF Components laboratory, headed by Dr L M Hollingsworth

For example, the idea behind Project Volir, a single radar using multiple stacked beams to provide information on target azimuth, range and height (normally requiring two separate radars) came out of this lab, Dr Hollingsworth says So did many of the techniques and components which made Volir possible, such as the use and phasing of 10 magnetrons to provide extremely high output power.

▶ **Lab Sections**—The RF Components lab is staffed by approximately 50 people, of whom roughly three-quarters are either engineers or what Dr Hollingsworth calls "super technicians" The lab is divided into four sections

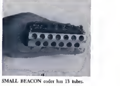
- Receiver Circuits.
- Modulator and MTI (moving target indicator).
- Transmission Lines
- Electron Tubes.

▶ **Receiver Circuits**—In recent months there has been more emphasis in the Receiver Circuits section on improved MTI circuit techniques to improve radar's ability to pick out targets from surrounding clutter

In the same section there are studies on the effects of frequency and pulse repetition rate on an airborne radar's ability to discriminate between different types of ground targets

Another area of activity is the design of tiny experimental subminiature radar beacons

▶ **The "Talking Monster"**—The Receiver Circuits section has devised an ingenious gadget, sometimes referred to as "the Talking Monster," or "Project



SMALL BEACON coder has 13 tubes.

AVIONICS

Talk-back." It permits a pilot or radio mechanic to check the transmission and reception of an airplane's communications equipment, without bothering control tower personnel. It could find application to civil air operations.

Gen. E. E. Partridge, returning from a visit to Korea, reported that pilots there would often call the control tower to ask whether their signal was getting through, diverting tower personnel from other duties.

► **Automatic Tape Recorder**—The Receiver Section's solution is a small tape recorder which is wired into the control tower radio receiver squelch circuit. When a pilot wants to check his radio gear, he tunes to the regular tower frequency and clicks his microphone button three times, which starts the tape recorder. The pilot identifies his aircraft, and says "Test, one, two, three." The recorder then plays back this test transmission over the tower's transmitter.

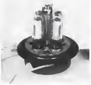
The entire check procedure takes only 10 seconds, and is completely automatic insofar as tower personnel are concerned. Maintenance crews checking radio equipment on the ground can also use the "talking monster."

The device uses a continuous magnetic tape rotating on a thin drum. It can be connected into the control tower receiver with a minimum of receiver modification, and without any change in the transmitter.

► **Static Signal Converter**—A static (non-vibrator) type of converter for changing d.c. signals to a.c. has been developed in the Modulator and MTI section.

The d.c. signal is applied to an argon glow tube whose light output excites photo cells to produce a proportional a.c. signal whose phase depends upon the polarity of the d.c. input.

Advantage of this photo converter over conventional vibrator choppers, according to Dr. Hollingsworth, is its high impedance input, lack of moving parts,



PHOTOCONVERTER uses argon glow tube to change d.c. signals to a.c.

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and its ability to operate on carrier frequencies up to 5 kc. He also says the device is more stable than conventional vibratory signal converters.

▶ **Other Projects**—Major activities of this section, as the name suggests, are in the field of magnetrons, pulse transformers, and MTI devices. The performance of each of these devices is heavily dependent on the characteristics of the other two.

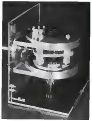
In addition to development work on magnetic modulators, this section often runs tests on new magnetic materials to obtain response characteristics that are needed by pulse transformers designers.

This data is sometimes converted to easy-to-use charts to simplify pulse transformers design. This section has analog computer capabilities.

▶ **Dielectric Waveguides**—As radar wavelength goes down, the waveguides used to transmit RF energy get smaller and more difficult to manufacture. The conventional metal waveguides also tend to become "loss-ier," Dr. Hollingsworth states.

This explains why the Transmission Line section is casting an eye at waveguides made of dielectric materials, particularly for the extremely high-frequency radars. The problem is that the present low-loss dielectrics (polystyrenes) are structurally weak when subjected to the very high temperatures that are encountered in highspeed jet aircraft.

One product of this section is a parallel plane tuner to vary the frequency of klystron tubes. It has enabled AFCRC to get 30 watts output power from a klystron rated at only 10 watts. The device achieves the increase by maintaining ideal alignment



PARALLEL plane tuner for klystron tubes increases available power output.

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of klystron elements during tuning Another development is a non-mechanical, instantaneous attenuator for radar transmission lines

▶ **Mathematical Vacuum Tubes**—Nonlinear vacuum tubes which can perform computing functions are one area of activity in the Electron Tubes section Current developments include a "square law" and "logarithmic" tube

The square law tube can, for example, be used to obtain the product of two quantities, each represented by a voltage ("X" and "Y") in the following way

The sum of the two voltages is squared in one tube, a voltage proportional to $(X^2 + 2XY + Y^2)$ The difference between the two voltages is squared in another tube giving a voltage proportional to $(X^2 - 2XY + Y^2)$ These two voltages are subtracted from each other, leaving a voltage equal to 4XY Then, by a voltage divider, one-quarter of this voltage is obtained to give XY, the desired product of the two quantities

▶ **Glass Blowers**—The Electron Tubes section has glass-blowing facilities which enable it to fabricate most of its experimental tubes within the lab

LAB BLOWS its own experimental tubes.

The only exception is hydrogen-filled thyratrons Present AFCRC facilities (in former old warehouse) are not considered suitable or safe for handling hydrogen

When pilot quantities of an AFCRC tube are needed, they are usually produced by outside tube manufacturers to AFCRC specs For example, the non-linear vacuum tubes are built by Raytheon Mfg Co

▶ **L-Cathode**—One current program is to improve the L-cathode developed by Philips-Eindhoven of Holland Potentially this type cathode is more rugged and can be operated at higher current levels However, Dr Hollingsworth says, U. S tube manufacturers have generally had trouble keeping the emitter material on the cathode The tube section is trying to solve this problem This section also develops neon tube noise generators, used to check receiver signals to noise ratio, for the ultra-microwave region where they are not commercially available, Dr Hollingsworth says

L-TYPE CATHODE and external anode are employed in this experimental tube

Antenna Lab

Research into the characteristics of electromagnetic radiation in the microwave region and development of devices to control radiation patterns has frequently caused the Antenna laboratory to turn to optical discoveries made 50-100 years ago, Dr Roy C Spencer, lab chief, told Aviation Week

In fact, the lab's professional scientists (approximately 20 in number) are mostly physicists and mathematicians rather than electronics engineers That is because at the very short wavelengths used in radar, electromagnetic radiation shows many of the characteristics of light

It is because microwave energy is scattered and reflected from solid objects, much like light, that radar is able to "see" these targets The strength of the radar echo, like the amount of light reflected from an object, depends upon the object's size, shape, and projected area

Because of this similarity the antenna lab has been able to study some of the properties of radar scattering, and compare the effective radar reflecting area of different shapes of aircraft by studying the amount of light reflected from small models

A small model aircraft is illuminated by a point source of light and a photograph taken from the same direction to record the amount of reflected light Balls of varying diameters are placed along side the model to serve as standards, i e to compare the amount of light reflected by a ball of known size with that reflected by the model airplane

▶ **Microwave Optics**—From the very early days designers have patterned radar antennas after the parabolic searchlight reflector In order to focus radar energy into a narrow pencil beam,

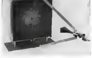
REFLECTED highlights on model and reference balls gives measure of radar energy that actual plane would reflect.

the source of radar energy is located at antenna's focal point.

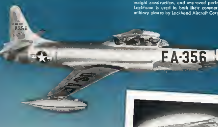
Although this practice is still widely used, other more sophisticated optical principles are being adapted to the shaping of microwave beams. One technique which has been explored in the Antenna lab is to place the microwave source behind a metal lens, consisting of many square waveguide tubes of varying depth. This metal lens focuses microwaves much like a common reading glass focuses light.

▶ **Antenna Designs**—An unusual antenna design, invented by Dr. Spencer, consists of two metal sheets, each bent in the form of a parabolic cylinder, but joined so that their principal axes are at right angles to each other. Energy radiated from a small horn inserted through a hole in one sheet bounces back and forth between the metal sheets and emerges as a parallel (collimated) beam.

For ground or airborne surveillance radars it is desirable to use a fan-shaped beam instead of a thin pencil beam.



METAL LENS focuses microwave energy.



DOUBLE parabolic cylinder antenna forms MW energy into parallel beams.

This can be accomplished by "distorting" the normal paraboloid shape of the antenna, or by using an extended microwave energy feed to the antenna.

A new technique, recently developed by Dr F S Holt and C J Sletter of the Antenna lab, uses a waveguide with slots milled in its side through which the energy "leaks." This technique has resulted in certain improvements, Dr. Spencer says

The shape of a radar beam generated by a microwave lens or aperture is determined by the relative phase and amplitudes of the electromagnetic fields in front of the lens or aperture. The Antenna lab has developed an extremely

PHASE and amplitude of microwave fields can be plotted on this device

useful device for checking antenna performance It is a machine which measures and plots phase and amplitude contours for various types of radiators

▶ **Microwaves on a String**—Unlike low frequency power, which can be transmitted over conventional wires, microwaves have required expensive and difficult-to-manufacture waveguides or coaxial cables

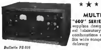
But a phenomenon discovered since the end of the war—that microwave energy will cling to the outside surface of a conductor—may permit the use of single wire transmission lines The Signal Corps, for example, has developed a "G-string" type of microwave conductor consisting of enamel-covered wire in which microwave energy clings to the enamel and the wire acts merely as a mechanical support

Other types of similar transmission lines are corrugated rods and ferrite coated wires They were first studied by Walter Rotman and F. J. Zucker of the Antenna lab here, according to Dr. Spencer He adds that single wire lines show promise of usefulness in the microwave region

▶ **Flush-Mounted Antennas**—Radar antennas have long been a thorn in the side of aircraft designers No matter where you hang them, radar antennas usually compromise clean aerodynamic design.

The Airborne Antenna section of the lab is experimenting with new types of radar antennas which can be flush-mounted with scarcely a bulge showing. These antennas could also eliminate the need for the considerable space within the airframe to permit the radar antenna to rotate or scan.

▶ **Twinkle, Little Star**—The growing interest in automatic star trackers for automatic celestial navigation has prompted more than romantic interest



in the twinkling of stars—the source of the reference signals that guide the star trackers

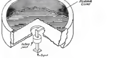
To Dr Heinz Fischer of the Spectroscopy section of the Antenna lab, this "twinkle" is plain "noise" And the ratio of signal to noise is most important for star trackers This is one of the research programs under way in this section

► **Hydrogen Reversal**—Among other problems under investigation is high-density gaseous spark discharge A spokesman says Dr Fisher has photographed the reversal of hydrogen lines, which indicates higher temperatures than had been previously reported in technical journals

Dr Spencer considers this an important milestone in the history of spectroscopy

► **Some Research Outside**—The Antenna lab farms out some of its research programs to universities For example, basic research in electromagnetic theory is done at New York University, slot radiation work at Brooklyn Polytech, and microwave optics at McGill University in Montreal

A recent four day symposium on microwave optics at McGill brought together some of the world's top experts in radar, antennas, optics, and information theory



FLUSH RADAR ANTENNAS are a "must" for jets

The nature of Antenna lab research involves considerable mathematics and computational work In addition to familiar desk calculators, the lab uses a recently obtained Monorobot digital computer, the first which Monroe Calculating Machine Co has delivered, according to Dr. Spencer.

Computer Lab

For several years, AFCRC engineers have been applying digital techniques to the processing of radar and other types of information Recognizing that these techniques will play an increasingly important role in future Air Force systems, AFCRC formed the Computer Lab to bring together some of the groups which have been working on digital techniques

The major efforts of this lab are devoted to digital data processing requirements, both current and anticipated, for systems under development by the Center In addition, the Lab maintains a Computional Section which provides mathematical assistance to AFCRC scientists by programming problems for solution on the Monorobot and the AFCRC-developed ABC (Automatic Binary Computer)

AFCRC expects these electronic computers to be useful in advance evaluation of the relative effectiveness of alternate system designs

Systems Project Office

Within the past several months, responsibility for all ground environment equipment used in the continental air defense system now under design has been delegated to AFCRC, and in turn

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to the Systems Project Office here.

The SPO was set up several years ago when AFCRC found that research and component development suffered when the same group tried to carry on systems engineering, according to Dr. Edwin G. Schneider

SPO also carries out sub system engineering to support the air defense program, the RADC tactical air weapons system program, or for miscellaneous projects This group does some "hardware" work, to the extent of assembling new components into a breadboard system to prove new system concepts developed within the SPO

However, SPO tackles component development only when the Component & Techniques group can't handle it.

▶ **Guiding Air Defense**—The SPO group to guide all air defense ground equipment development activities is now being formed. Headed by M A Chaffee, its job is to survey the entire air defense program to determine the compatability of individual portions of the system.

For example, AFCRC must see to it that the Hughes Aircraft fire control system, to be used in our newest interceptors, will cooperate properly with the ground-based equipment Anti-craft missiles and their ground avionic equipment, must also be integrated into the system

Air defense project will also look for possible duplication of efforts, as well as areas where more work is needed

The group itself will probably be small, made up of individual specialists in such fields as radar, data handlers, data link, missiles and interceptor fire control, to mention a few.

AFCRC is not new to air defense work For several years an AFCRC group has been working in the Lincoln laboratories on one phase of the overall system In addition, Lincoln labs have brought specific research and component development problems to AFCRC for work in its labs

▶ **Specs for Hardware**—One important SPO task will be to prepare specifications for the procurement of prototype equipment for the air defense system Actual procurement will be handled by the Air Materiel Command, and a small AMC unit may be located at AFCRC for closer liaison

Larger contractors may have an edge in the early phases of the program, because most of the contracts will be for large complex sub systems

Later, when the system is proven, and performance tolerances can be established for individual components, it should be possible to bring in more small contractors, a spokesman indicated.

▶ **Traffic Control Computer**—A system designed to schedule automatically the orderly flow of air traffic in the area around an airfield to permit the landing of two aircraft per minute (per instrument runway), is another SPO program

Called Project Volscan, the system consists of a track while scan radar which supplies azimuth as well as range data on all aircraft in the area to an analog computer which schedules their approach to a GCA or ILS "gate."

▶ **Picking a Slot**—When a new aircraft enters the controlled area, it is picked up by the radar and the computer calculates its earliest time of arrival at the final approach gate, based on its present position, altitude, and speed

If this earliest time of arrival does not conflict with other aircraft, the new aircraft continues straight in If there is a conflict, the computer looks for the next vacant "slot," and then calculates a detour course which will bring the new airplane in at the later time

In the event the newly arriving airplane has lost an engine or is suffering battle damage, the computer can be instructed to "bump" one of the previously scheduled aircraft to make way for the emergency approach

▶ **Automatic Flight Control**—Although the scheduling calculated by the computer is presently transmitted orally by radio, the same information could be transmitted by data link to give each pilot visual steering instructions and/or provide signals to the plane's autopilot to control its flight path automatically

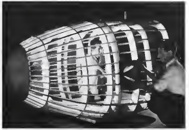
The 1953 Thurman H. Bane award for outstanding achievement in aeronautical development was recently made to Benjamin F. Green, Jr. of AFCRC for his work on Project Volscan

▶ **Project Volir**—During World War II, two separate surveillance radars were used jointly, one to determine target azimuth and range, the other to measure target height.

Shortly after the war, Cambridge launched Project Volir—the development of a single radar and single antenna capable of simultaneously providing azimuth, height, and range data

But it recognized that a three-dimensional radar, such as Volir raised display and "bookkeeping" problems How do you display and keep track of hundreds of targets in three dimensions on a cathode ray tube which has only a two dimensional display capability?

AFCRC's solution was an automatic digital tracking analyzer computer (ADTAC) which accepted data from the Volir radar and kept a running record of the range, azimuth, and height of up to 400 different aircraft ADTAC would produce this data (plus target velocity) for any specific target upon "request" of its human operators ADTAC was tested last Summer and the results are currently being evaluated



SIGHT AT NIGHT requires a plane to carry many antennas, like one shown in mock up.

WADC's Aircraft Radiation Lab:

Where AF Perfects Radar 'Eyes'

Dayton, Ohio—How can you spot two dozen enemy tanks moving up under cover of darkness when you're zooming overhead in a 600-mph jet?

How do you pick out an important strategic target on a bombing radar scope when you don't know the target's exact location relative to known landmarks?

And when there are no distinctive landmarks, how do you train radar bombardiers to familiarize them with how an enemy landscape will appear on a radar scope?

These are some of the knotty problems under investigation in WADC's Aircraft Radiation Laboratory, which might more aptly be named "The Sixth Sense Lab."

► **Mission Vision**—ARL's mission is to develop techniques and equipment which will enable our airmen to extend range of their vision and enable them to penetrate darkness and overcast to see and identify enemy aircraft, and strategic or tactical targets.

Another important ARL mission is to develop airborne countermeasures equipment capable of neutralizing enemy airborne and ground-based radar and communications.

► **ARL Branches**—Headed by Col. C. H. Lewis, the Aircraft Radiation Laboratory is divided into six branches:

- **Advanced Development**, under P. J. Snider.
- **Countermeasures**, under George Rappaport.
- **Search Radar**, under C. J. Marshall.
- **Guidance Development**, under R. E. Houser.
- **Design Engineering**, under C. N. Keher.
- **Installation Engineering**, under R. M. Worley.

Advanced Development

"We get lots of 'stuff' on our radar scopes that we don't understand which may have important significance and which could be sorted out," according to F. L. Holloway, Technical Director of ARL. "We need to get more basic information on the significance of radar return," he adds. This is the kind of assignment delegated to ARL's Advanced Development branch which does much of the applied research within the Lab and most of its in-house development. This branch is divided into three sections:

- **Wave Propagation.**
- **Antenna Design.**
- **Applied Physics.**

► **Wave Propagation Section**—Overly enthusiastic claims sometimes made for radar tend to obscure the fact (to those outside the radar field) that looking at a bombing radar scope is a far cry from looking out a visual bombsight on a clear day. Reading a radar scope involves considerable interpretation, much of it of an empirical nature. That is what Holloway means by his statement about "lots of stuff on our radar scopes that we don't understand."

One program underway in the Wave Propagation section is intended to find out more about how specific types of terrain and materials look on radar

That is, what kind of signal returns (echoes) are received from different types of terrain and what are their distinguishing features

▶ **Studying the Pulse**—Airborne targets return only a small amount of radar energy, often making them difficult to detect in the presence of energy reflected from moisture in the air. The WP section is analyzing the echo signals from airborne targets in an attempt to extract all possible information from them. As a part of this study, the WP section needs to analyze each individual pulse of echo energy, rather than the average signal which appears on a radar scope.

Another propagation study in this section is aimed at determining the cause of sporadic fading in radio air-to-air communications

▶ **Antenna Design Section**—Applied research into the design of airborne radar and countermeasures antennas for operation at frequencies "from d c to infrared—whatever the enemy chooses to use," is the way Fanning describes the problem of the Antenna Design section. The solution becomes more difficult for highspeed aircraft, Fanning points out, where antennas must be flush-mounted or nearly so

As possible solutions, the AD section is investigating recessed and slot antennas as well as exciting portions of the airplane fuselage or empennage to serve as a radiator.

Asked about progress, Fanning says it has been "considerable" "We have been able to design flush antennas to give the desired radiation—but not at all the frequencies, yet," he says

Fanning notes that ARL has a very complete antenna testing facility, possibly the best in the country

▶ **Applied Physics Section**—The Applied Physics section is devoting most of its efforts to developing ultra-sensitive infrared detectors and studying the propagation characteristics in this region.

Generally speaking, infrared has the same distance limitations as visible light. Hence it appears attractive for night operations, but not too good for operations in rain or mist. ARL views infrared as a supplemental aid to radar and not as a potential replacement for it, Holloway says

Countermeasures

Airborne Electronic Countermeasures (ECM) is the science of denying the enemy any advantage that he might gain in his use of electronic systems designed to defeat our aircraft or missiles. Most of the Air Force's airborne ECM work is carried out in the Countermeasures branch here.

▶ **Easier and Harder**—In one respect airborne ECM engineers have an easier job than their ground based counterparts at Rome Air Development Center, in another sense their job is much more difficult. The job is easier for WADC because electro-magnetic radiation doesn't respect or stop at national boundaries

Thus by the very nature of the problem, the airborne ECM engineers get some advanced information on the characteristics of the ground equipment which they may be called upon to jam in event of war, while the ground-based equipment engineer never knows what airborne ECM will be thrown at him until war breaks out.

▶ **Other Side of the Coin**—The airborne ECM engineer has his problems, though. ECM has to compete for space and choice location on a bomber with such things as fuel tanks, bombing systems, and armament. The weight, size, and complexity of airborne jamming equipment is necessarily limited because it must be carried in an airplane.

The ground radar designer, effectively without any of these limitations, can go to great pains to build in sophisticated anti-jamming circuits. What is more, he has a great deal of power to "play with," while the airborne jammer must operate with much more modest powers

In neither case does the ECM engineer, have a bed of roses in his work

Col Lewis told Aviation Week that he believes that "ECM requires as much technical skill and ingenuity as any other equipment under development in ARL." He adds that the ECM art is so "sophisticated and complex" that the majority of these developments must be given to contractors with considerable technical capability

▶ **ECM Activities**—The Countermeasures branch is divided into five sections

- Reconnaissance
- Jamming Systems
- Chaff Systems
- Deception
- Research

For security reasons, Holloway declined to discuss details of the work in each of the sections, except to outline their general areas of activity. For example, the Reconnaissance section develops airborne equipment designed to search the RF spectrum, analyze, and record enemy radiation

The Jamming section develops equipment which creates RF "noise" to block out enemy ground or airborne radars. The Chaff systems section develops new types of chaff and airborne dispensers

As used in World War II chaff consisted of finely shredded pieces of aluminum foil which were dumped out by our bombers. The chaff drifted slowly earthward, reflecting energy from enemy ground-based radars creating the illusion of false targets and cluttering the enemy radar scopes

The Deception section devises new electronic methods for creating confusion among enemy radars. The Research section presumably serves all of the other sections in the branch. Roughly 25% of the Research section's work is in-house development, Col Lewis says. Practically all developments in the other five sections are contracted out

Asked how the Countermeasures Branch tests the effectiveness of its ECM, Col Lewis replied that new components are tested against RADC equipment at Air Force Armament Center. He points out, though, that ECM is a never-ending race. The enemy can be expected to develop techniques for countering our ECM

Search Radar

The application of airborne radar and television equipment to get more aerial reconnaissance information faster, is being studied in the Search Radar branch.

▶ **Search sections**—The Search Radar branch is divided into five sections

- Radar Reconnaissance.
- Surveillance.
- AMTI (air moving target indicator).
- Display.
- Television.

▶ **Radar Reconnaissance**—In recent

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years there has been a great improvement in the overall quality of reconnaissance radar (used for ground mapping), according to C J Marshall, branch chief This improvement is partly due to improved receiver and display circuitry and better cathode ray tubes, Marshall says, and partly to improved techniques for photographing radar scope displays

Previously, provisions for attaching cameras to radar scopes were fairly crude and fixed-focus cameras were used, Marshall says The result was that the picture was frequently out of focus and fuzzy

New techniques developed in the Radar Reconnaissance section enable an operator to check the focus of the camera on the scope, and make adjustments if necessary This section has also devised new controlled techniques for developing and printing radar scope photos to show greater detail

However, the primary task of this section is to develop new search radars Frequently these developments are later adapted to other uses, such as for bombing systems

The distinction between search and navigation radars is this, according to Holloway Search radars, used for ground reconnaissance mapping usually require greater precision than navigation radars

▶ **Surveillance Section**—The term surveillance radar is applied to airborne radar used to detect other aircraft (or missiles) The Surveillance section is developing airborne equipment for both the Air Defense Command and the Tactical Air Command for use as early-warning radars

By "hoisting" radars up to considerable altitudes, their range, which is limited by the earth's curvature or horizon is extended considerably

▶ **AMTI**—The use of airborne radar in ground support action has not, in the past, been practical because it is too difficult to pick out slow moving targets from the "ground clutter" (echoes returned from stationary ground objects)

Moving target indicators (MTIs) have been used for some years in ground-based radars to sort out aircraft from spurious echos, but the problem is much easier there For one thing the unwanted clutter comes from fixed ground objects while the wanted airplane echo is moving, making it possible to discriminate (electronically) between the two

The airborne MTI problem resolves itself into this The airplane and its radar are moving at, say, 500 mph the target (a tank or truck) is moving at 20 mph Relative to the radar the ground is moving at 500 mph and the

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truck at 480 (or 520) mph The object is to "throw out" signals received from the object moving at 500 mph, while retaining the echo signal from the truck or tank moving at 480 mph The criterion for discrimination between wanted and unwanted signals is obviously a very narrow one

Despite the difficulty of the problem, Marshall reports that the AMTI Section has "made considerable progress and some specific hardware is in sight." During the lean years of 1946-48, the work was carried on in-the-house, Marshall says Now it is contracted out

AMTI must be engineered into airborne radars and cannot be added to existing ones, as a general rule, Marshall says The reason, he explains, is the need for greater stability in some of the radar circuitry Part of this section's job is to pass along its AMTI know-how to industry engineers under contract to the Radar Reconnaissance section, Marshall says

► Display Section—"Predicting, or synthesizing, the radar picture which would be obtained over unexplored, unfriendly territory is a tough problem," is the way that Marshall describes one of the current investigations in the Display Section "You can't go to the literature, like the MIT Radiation lab series, for the answer either," he adds Marshall points out that you can't always rely on natural landmarks The Mississippi River, for example, with flat land on either side of its banks, would appear quite differently on a radar scope than the Hudson River which has high rocky cliffs along its banks (in some areas)

The direct opposite of this "synthesis" work is a systematic study of how to interpret radar scope presentations to distinguish different types of terrain and buildings This program, the results of which are so important to the use of radar for reconnaissance, is being carried out jointly by the Display and Propagation sections of ARL

► Color Displays—The Display section is currently experimenting with color cathode ray tubes for possible radar application in the hope of making it easier to discriminate between different types of terrain and targets The idea is to use different colors to indicate the relative signal strength of the returning radar echo—in effect adding a third dimension to radar displays This section also develops new types of radar displays with an eye cocked at the human engineering aspect of their design The section works closely with the WADC Aero-Med Lab, Marshall says

From the air, landmarks look considerably different on a radar scope than to the human eye, which makes conventional aerial maps of little value in radar navigation The answer is to give navigators "radar maps" showing the area as it appears on a radar scope The display section is developing techniques and computers to speed up the process of preparing radar maps

► Television Section—"Television offers attractive possibilities for aerial reconnaissance," Marshall says, "because the intelligence can be instantly transmitted back to headquarters"

Techniques developed in the Television section of the Search Radar branch can be applied to aerial mapping under visual conditions, to radar mapping under overcast conditions, and to the remote control of drone aircraft, Marshall notes In the latter application, TV is used to show the cockpit instruments in the drone airplane

Advantage of TV over radio telemetering, Marshall points out, is that TV is fail-safe If a picture is being received—the operator on the ground knows that he has an accurate indication of drone cockpit instrument readings

► Photos Used—When TV is used for direct photo reconnaissance in a high-speed aircraft, little information can be obtained by directly viewing the TV screen For that reason the picture is recorded on film on the ground so that it can be replayed at slower speeds Another type of reconnaissance technique is to make a mosaic photograph of a large area

Present efforts of the TV section are devoted to devising new techniques to reduce the bandwidth required to transmit the TV picture One technique involves the use of very low frame rates. To eliminate the flicker that normally accompanies low frame rates, the section is trying a "dot interlace" scanning technique instead of using the conventional sequential interlace

Guidance Development

How do you quickly rendezvous thirsty jet bombers with their tanker aircraft for air-to-air refueling? How can jet bombers keep their station (position) when flying formation in instrument weather These are a couple of the problems under investigation in the Guidance Development branch.

► Guidance Groups—The Guidance Development branch is divided into five sections

- Altimeter.
- Anti-Air Techniques.
- Anti-Surface Techniques.
- Radar Techniques.
- Radio Control & Telemetering.

► Altimeter Section—Radio and radar altimeters, developed in the Altimeter section, are not normally thought of as

guidance devices, although they do have important uses as such, R. E. Houser, branch chief, points out.

For example, in photo reconnaissance work, it is important that the airplane remain at a fixed altitude above the terrain. This can be achieved by tying in a radio or radar altimeter to the airplane's automatic pilot. Height above the terrain is also important to troop carriers transporting paratroopers.

A new radar altimeter has been developed by the Altimeter section which eliminates the old cathode ray tube type of cockpit indicator and substitutes a Veeder-counter and pointer type indicator, Houser says.

Although the device weighs slightly more than its predecessor, the new altimeter has a greater operating range and is less complex, Houser notes. The new radar altimeter will shortly be in production. It can be used for automatic altitude (terrain clearance) control of both piloted aircraft and missiles.

► **Obstacle and Tail Warning**—One program which has just gotten under way is to develop an obstacle warning device, capable of detecting not only mountain tops, but smaller objects like buildings, towers, and even high-tension wires.

Another program is pointed toward a device which will warn a fighter or tactical bomber pilot when an enemy plane is on his tail. Functionally similar devices were used during World War II, but when used on low flying aircraft, reflections from the ground created false warnings.

Object of the new development is to eliminate false warnings from ground return, to extend the operating range of the tail warning radar, and to make it possible to detect smaller targets, such as air-to-air missiles Houser indicates.

► **Anti-Air & Surface Sections**—The Anti-Air and Anti-Surface Techniques sections have responsibility for technical guidance of radar techniques used in air-to-air, ground-to-ground, and air-to-ground missiles, operating through the armament laboratory and/or the Weapons Systems Joint Project Office. This includes such pilotless aircraft as the B-61 (Matador) and the Hughes Aircraft F-98 (Falcon) air-to-air missile.

The Anti-Air section also has the projects for developing rendezvousing and station-keeping techniques and equipment.

► **Radar Techniques Section**—New techniques designed to improve the range, accuracy and resolution of bombing and fire-control radar are initially developed in the Radar Techniques section. Its work includes the investigation of new operating frequencies for radar.

Most of this section's developments are performed by outside contractors.

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A recent exception is a new range radar for computing fighter gunsights. The section here built up the breadboard model, and then "sold" it to the Armament Lab, which is putting it into production, Houser says.

▶ **Radio Control & Telemetering Section**—Receivers and transmitters, which can be used either in the air or on the ground for the remote control of aircraft and target drones, are products of the Radio Control & Telemetering section.

In addition to these familiar uses, remote control set-ups are handy for running aerodynamic tests on new missile airframes before the missile's own guidance system is ready for use, Houser points out.

Remote control equipment developed by this section is used at other ARDC bases, Houser says.

Telemetering equipment for transmitting data from experimental airplanes or missiles under flight test to ground stations for recording and analysis is also a responsibility of this section. Houser says that pulse-coded modulation is generally used in preference to FM/FM because it can be relayed more easily without deterioration of its accuracy. Another advantage is that it can be recorded directly on IBM cards without intermediate conversion equipment, Houser adds.

Design Engineering

Most of the activities of the Design Engineering branch cut across the lines of other branches in ARL to achieve uniform design engineering practices throughout the lab.

▶ **Design Sections**—The branch is divided into four sections.

- **Anti-Jamming Research.**
- **Requirement & Analysis.**
- **Standards.**
- **Instrumentation.**

▶ **Anti-Jamming Research**—"Although the methods and progress achieved are highly classified, it can be revealed that research in anti-jamming techniques has resulted in considerable optimism in an area that only a few years ago was considered nearly devoid of solution," an ARL spokesman says.

Research and development of techniques to make our radars and guidance systems resistant to enemy ECM are the responsibility of the Anti-Jamming Research section. This section also acts as a consultant to other ARL Branches and other WADC labs to see that new anti-jam techniques are passed on to industrial contractors.

Another AJR section task is to evaluate airborne equipment to determine its susceptibility to ECM, and then to rate it with a "jamming susceptibility factor."

▶ **Standards Section**—The Standards section engineers work through project engineers in other ARL groups to see to it that newly developed equipment meets AF needs in terms of producibility, reliability, tactical suitability, ease of maintenance, and configuration.

This section tries to avoid the use of critical materials and to spot mis-application of components. All development specs are reviewed here before being issued, and the group works with AMC on ARL equipment.

Another task is to study and consider the application of new components to ARL equipment.

▶ **Requirements & Analysis**—When a contractor delivers a new piece of equipment, it goes to the Requirements and Analysis section for test and evaluation.

This group checks to see whether it meets the contract specs and other requirements established by the Standards section.

▶ **Instrumentation Section**—Should test devices be built into a new piece of equipment or should separate external testers be used?

The Instrumentation section studies each new development to determine how to minimize the amount of external test equipment required. If a specialized piece of external test equipment seems desirable, this section monitors its design.

Other activities include devising special testing techniques and inter-service standardization of common test gear.

Installatians Engineering

Developing a new radar or ECM, and putting it into production, is only part of the job that must be done. The best designed radar set will give just so-so results if not properly installed in the airplane, or if the radar operator can't conveniently reach its controls.

The Installations Engineering branch sees to it that ARL equipment is properly installed from both an engineering and a human-engineering viewpoint; that it is compatible with other equipment on board, and that it can operate from the existing power supply.

Branch personnel plan and direct the installation of ARL equipment in both piloted and pilotless aircraft. The branch provides installation data equipment specs, drawings and instructions for bench test and flight test. It also provides liaison engineers to work with contractors, Weapons Systems project officers, testing facilities, or installation and maintenance facilities.

The branch also functions to provide "feedback" to ARL project engineers on what type of installation problems may be encountered with new equipment in new aircraft and missiles.

NEW ILS LOCALIZER gives straighter low approach beam, allows easier alignment

Communications & Navigation Lab Reports . . .

Automatic Navigation Is Nearer

Dayton—"We have made nearly unbelievable progress in the field of self-contained airborne navigation systems," a spokesman for WADC's Communications and Navigation Lab says. This C&N Lab statement is encouraging because aircraft and missiles which can navigate without depending on signals from ground stations are practically impervious to enemy jamming and thus less vulnerable to enemy countermeasures.

This lab is responsible for development of airborne navigation systems, airborne communications equipment, certain terminal area aids (both airborne and ground-based) and avionic rescue aids.

▶ **The Lab's Work**—There are other interesting developments in the C&N lab, including:

- **Dead-reckoning computers.**
- **Tiny "handie-talkie" radios for rescue of downed pilots.**
- **Automatic rescue beacon for locating downed aircraft.**
- **Flareout adapter for near-automatic landings.**
- **Automatic tuning HF transceiver.**
- **Airborne teletypewriter.**

▶ **Six Branches**—The C&N Lab, headed by Col. C. U. Brombach, is divided into six branches:

- **Self-Contained Navigation,** under H. S. Rosenberg.
- **Ground Reference Navigation** under C. S. Franklin.
- **Communications,** under G. H. Scheer, Jr.
- **Techniques,** under R. E. Kester.
- **Test,** under J. E. Chamberlain.
- **Installations,** under C. A. Ahalt.

▶ **SCN Branch**—Self-contained navigation systems are comparatively new. Until late in World War II, dead reckoning involved essentially the same laborious manual techniques which had been inherited from the sea. Aerial celestial navigation used manual sextants which were fundamentally the same as those that are used on shipboard.

Navigational radar was one of the first self-contained navigation systems to come into use, late in the war. Another was an electro-mechanical computer used in the B-29 to perform most of the navigator's dead reckoning computations for him.

A much-improved dead-reckoning computer, the A-1, has been developed by the Ford Instrument Co., under the sponsorship of the Self-Contained Navigation branch. Another development, the AN/APA-58, combines a dead-reckoning computer and an airborne radar to provide further improved navigational accuracy.

▶ **A-1 Computer**—The navigator or pilot sets into the A-1 computer the plane's initial latitude and longitude, wind velocity and heading, and magnetic variation (difference between magnetic and true north). Information on airplane speed and magnetic heading are fed into the A-1 automatically during flight. The device continuously calculates and indicates airplane position in terms of latitude and longitude.

Instrument accuracy is reported to be 1% of the total distance traveled. In actual use, errors may run somewhat higher if accurate data on wind direction and velocity is not available throughout the flight.

▶ **AN/APA-58**—The new AN/APA-58, developed by Eclipse-Pioneer, gets added information to compensate for changes in wind velocity and direction by virtue of being tied into a radar, such as the AN/APS-42.

Radar beacons on the ground, or other known landmarks appearing on the radar scope can be used to re-establish true airplane position at frequent intervals and/or to determine wind velocity and direction.

▶ **Inertial & Celestial Systems**—"Things which would have been considered completely impossible and fantastic in 1946, nobody questions today," so says L. B. Hallman, C&N Lab technical director in describing progress in automatic inertial and celestial navigation systems.

There is no secret about some of the principles involved in either type of system, reducing these principles to working hardware is the real problem.

A patent granted last year for an inertial navigation system stated the fundamentals for one such type of system. It involved the use of accelerometers mounted in an airplane in such a way as to measure its acceleration relative to the earth. A double integration of the accelerometer signal gives distance traveled—much easier to say than to do to the required accuracy.

▶ **Star Tracker**—An automatic celestial navigator might consist of two star trackers—telescopes with photoelectric cells suitably gimbaled and positioned by a servo system so as to keep each pointed at its assigned star. This is equivalent to the two sightings normally taken by a human navigator with a manual sextant.

Telescope positions relative to a vertical and azimuth reference (as required in manual sightings) would be fed into a computer which could determine the craft's latitude and longitude.

Both automatic inertial and celestial navigation systems are useful in missiles where there are no navigators or human operator to set in the inputs required for dead-reckoning devices.

A spokesman says the trend is toward using digital (rather than analog) computers in the new navigation systems, but there are still reliability problems involved in this type.

The SCN branch also develops special types of navigation radars, compass-slaved gyros, manual sextants and associated dead-reckoning and celestial navigation accessories.

▶ **GRN Branch**—Two recent developments in the Ground Reference Navigation branch show promise of lower visibility and ceiling requirements for landing military aircraft. One is the APN-71 flareout adapter, developed by Hazeltine; the other is improved ground-based ILS equipment. Both are under the cognizance of the GRN Branch's Terminal Aids To Approach & Landing section.

▶ **Low Approach System**—The ILS (instrument landing system) is really a misnomer; it currently is only a low approach system down to 100-200 feet for military aircraft.

To permit instrument weather approaches to even lower altitudes, the AN/APN-71 was designed to furnish guidance signals for the flareout after leaving the ILS glide-slope. The device's guidance signals can be displayed

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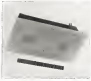
on the ILS cockpit indicator, and can be connected into the plane's autopilot for an automatic flareout, if desired.

▶ **Flareout Adapter**—The APN 71 consists of an FM altimeter, which measures airplane height from the ground, and a computer which calculates an ideal exponential flareout path for the airplane The device can be set to cut in at a preselected altitude so that there is no discontinuity between the glide-slope and the flareout signals



FLAREOUT adapter used for low ILS approaches and as terrain clearance indicator

If, during the flareout, a gust causes the plane to deviate from the previously computed flareout path, the computer instantly computes a new flight path (based on the new altitude) rather than trying to keep the plane on the original path

Flight tests of the APN-71 indicate that it can be used for completely automatic touchdown in slower aircraft However, C S Franklin, branch chief, views the device as a means of extending the low-approach capabilities of ILS. By virtue of its radio altimeter, the APN 71 can also serve as a terrain clearance indicator

At present the device's maximum effective altitude is 200 ft, but Hazeltine is working to increase this value

▶ **Improved ILS**—New antenna arrays which have been developed for Air Force ILS installations not only give much improved beam linearity, according to Franklin, but they are much easier to site and align, an important consideration for military operations

The new MRN-7, -8 localizer and glide slope transmitters are much more reliable, Franklin adds, and they are being installed in duplicate with automatic switchover in the event one transmitter fails

The Terminal Aids section is also responsible for the development of ILS airborne receivers One current program at Crosley Div of Avco Mfg Corp is the AN/ARN 31, a subminiaturized combination localizer and glide slope receiver for use in aircraft which

do not have (or need) omnirange receivers that cover ILS localizer frequencies

▶**Navaglobe Future in Doubt**—The Medium & Long Distance Navigation section of the GRN branch is developing a production prototype of an airborne receiver to operate with the Navaglobe long distance "omnirange" system under investigation at RADC.

Although lab people speak well of Navaglobe's capabilities, they think it is better suited to civil airline operations than to military needs Federal Telecommunications Labs, which developed Navaglobe, is building the prototype receiver It will be housed in a ½ ATR, making it comparable in size to present VOR receivers, Hallman says.

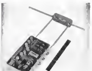
▶**Loran and ADF**—Airborne Loran receivers capable of operating with RADC developed systems are assigned to this section, which is also responsible for airborne automatic direction finders

The Short Distance Navigation section is responsible for VOR receivers, course-line (offset track) computers, and similar types of navigation equipment

▶**Life Savers**—In Korea, a tiny "handy talkie" VHF/UHF radio transmitter/-receiver, developed by the Air Rescue section of the GRN branch is credited with helping to save the lives of 150 airmen downed behind enemy lines in a three-month period Thirty of the men gave complete credit for their rescue to the handy talkie

The device, called the AN/URC-4, weighs only 6 lb. and is tiny enough to be carried by flight personnel in their pockets When downed behind enemy lines, an airman can call for help, giving his location and warning of nearby enemy troops The device can also be used to guide recue helicopters in over hazardous terrain The battery supply is good for 24 hours of operation

▶**Crash Locater Beacon**—Another life saver development in the Air Rescue section is an aircraft crash locater beacon for use in conjunction with a



"HANDY TALKIE," shown with cover removed.

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world-wide rescue network involving ground-based detectors and direction finders under development at RADC.

The beacon under development here will be carried inside of an airplane and will be catapulted out in the event of a crash. Upon landing on the ground (or in water—in which it will float), legs automatically extend to erect the beacon, an antenna mast is automatically extended, and the beacon then begins to transmit a specially coded SOS which identifies the aircraft and the interval since the crash.

AIRMEN carry small **VHY/UHF** Handy Talkie to call for help when downed.

RADC developed ground-based stations will instantly take bearings on this crash beacon and feed the data to a centralized control point where a computer will calculate the most probable location of the crash.

▶ **For the Busy Pilot**—When a pilot finds himself in an emergency, he's usually too busy to radio an SOS, give his position, and operate his transmitter long enough for a ground-based direction finder to take a bearing. AF bombers and transports are currently being equipped with a small device, called an automatic keyer, that does all this automatically for the pilot. When he throws an emergency switch, the automatic keyer turns on his HF transmitter, tunes it to the emergency frequency, starts keying an SOS and another code which identifies the plane, and provides a signal which can be used by ground direction finders.

The device was an in-house development of the C&N lab.

▶ **Communications Branch**—One of the major problems facing the C&N lab is to increase the reliability of long distance air-to-ground and air-to-air HF communications.

Reliable transmission from aircraft is much more difficult than from ground-based equipment. For one thing, ground stations can use large directional antenna arrays, an impossibility in aircraft. The use of flush mounted antennas further limits aircraft radiation compared to ground stations.

▶ **Simplified Tuning**—On the favorable side of the ledger, complex tuning procedures previously required in operating HF airborne radio equipment have been greatly simplified by a recent development sponsored by the Communications branch.

It is a new HF transceiver (AN/ARC-21) which is very nearly automatic, Hallman says. The set was developed by Radio Corp. of America and is now in production. With the new ARC-21, the pilot pre-selects more than a dozen operating frequencies before leaving on his mission. During the flight the pilot need only position the selector switch to any one of these positions, and the HF receiver, transmitter, and antenna are automatically turned to that preselected frequency.

▶ **Airborne Teletypewriter**—The Long Distance section also has under development a lightweight airborne teletypewriter that will enable an aircraft to receive or send teletype messages. The device, which is expected to weigh about 50 lb., will include a tape cutter and transcriber so that incoming or outgoing messages can be "taped" for delayed transmission or transcribing. The new airborne teletypewriter will

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be designed to operate from the ARC 21 which has provision for frequency shift keying (FSK) circuits

Teletypewriter communication has several advantages over voice communications in certain applications For one thing, an incoming message can be received without diverting the flight crew from other duties Also, there is less chance of misunderstanding long complex messages if they are printed rather than spoken A further advantage is that the system operates on a narrower bandwidth than normal voice communications

▶ **Emphasis on UHF**—The Short Distance section of the Communications branch is primarily concerned with UHF, which is replacing VHF throughout the military services

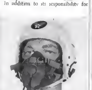
A spokesman says that a new miniaturized UHF transceiver has been developed by RCA and is going into production This new AN/ARC 34, which will replace the present ARC 27, is about half the size and weight of its predecessor

▶ **New Hi-Fi Intercom**—The first completely integrated airborne intercommunications system (including public address system where needed) was sponsored by the Accessories section of the Communications branch It is the AIC 10, developed by RCA and currently in production

The new system provides improved fidelity and understandability despite high cabin background noise, Hallinan says In addition, the system is smaller and lighter and the mike and earphones have been specifically designed to fit under the plastic crash helmets worn by jet pilots

The AIC-10 eliminates carbon microphones—sometimes called the world's most expensive 'loose connection'

In addition to its responsibility for



HEADSET of AN/AIC-10 curves under helmet; mike is built into oxygen mask.

RCA'S AN/AIC-10 is first interphone system designed to fit in crash helmet.

CONTROL PANEL permits pilot to select any desired radio or intercom circuit.

intercoms, mikes headsets, and loudspeakers, the Accessories section also develops airborne wire and tape recorders

▶ **Data Link**—Airborne receivers for radio data link systems (used to transmit instructions to individual aircraft and to permit ground control of individual aircraft flight path) are under development by the Specialties section of the Communications branch

The work includes the development of suitable cockpit instruments to display ground instructions sent over the data link

This group helped to develop the airborne adapter which permits automatic GCA guidance signals to be transmitted to the aircraft cockpit using the plane's regular communications receiver without disrupting normal voice communications

This section also follows various types of frequency-control components such as crystals and magnetostriction devices

▶ **Techniques Branch**—Research and development of special techniques which can be applied to several or all fields of activity in the C&N lab are the responsibility of the Techniques branch

For example, the Antenna section acts as a consulting group and reservoir of antenna design knowledge for all C&N projects, and has consulting contracts with the country's top antenna experts

Right after the war this section had the task of developing techniques to design flush-mounted antennas in order to eliminate protuberances from high-speed aircraft

Another part of the job was to convince aircraft manufacturers that antennas could be built into the fuselage, empennage, and wings

▶ **Flush Antennas**—To convince the industry, and arouse interest, the Antenna section designed and installed flush-mounted antennas in a C-54 for a variety of different types of avionic equipment, including UHF, VHF, HF, ADF, ILS, marker beacons, loran, radio altimeter and radar The plane is believed to have been the first to completely eliminate external antennas

Originally much of the flush-antenna design work was done here in the C&N lab, but now the aircraft manufacturers have assembled staffs to take over this responsibility The Antenna section gets back into the act when a fundamentally different type of flush antenna is needed by the aircraft industry

▶ **Scale Models**—The advent of flush-mounted antennas, whose shape and location affect the structural design of the aircraft has meant that antennas may no longer be "hung" on the air frame after it has been designed

Today antenna performance must be evaluated by means of tiny scale models before the airframe design is frozen, an Antenna section spokesman points out

▶ **Chasing Shadows**—UHF flush antennas have given some trouble because high frequency energy is reflected from or shadowed by the fuselage and wings resulting in blind spots (points of weak signals) in certain directions

The most promising solution to this problem, an Antenna section spokesman says, is the use of several antennas (diversity antennas) located in different portions of the airplane The transmitter, or receiver) is then continuously switched from one antenna to another Current efforts are being devoted to finding the best place to locate the several antennas and how to switch from one to the other

▶ **Other Sections**—Other sections in the Techniques branch and their general areas of responsibility include

• **Interference reduction:** Develop techniques and circuitry to minimize the effect of precipitation static, lightning and similar natural interference, as well as protecting against interference generated by man-made equipments

• **Anti-jamming & security techniques:** Research in new techniques to make C&N lab-developed equipment resistant to enemy jamming

• **IFF & military traffic control** Avionic identification systems, including air-to-air IFF, airborne equipment to identify aircraft to ground based traffic

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control radars, and air-to-ground beacon navigation systems for use by troop carriers.

Two important supporting service groups within the C&N lab are the Test branch and the Installations branch

▶ **Test Branch**—The Test branch is divided into three sections with the following responsibilities

- **Engineering facilities**: Handles ground radio and similar ground facilities needed in flight testing
- **Equipment evaluation**: Handles test data reduction and analysis.
- **Flight operations:** Handles flight test arrangements with WADC Flight Test division and schedules operations

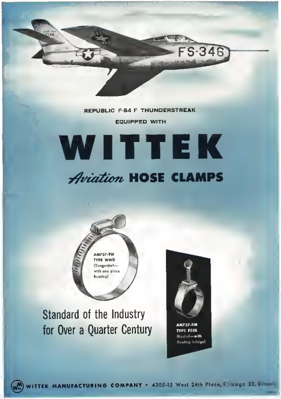
▶ **Installations Branch**—The Installations branch provides aircraft manufacturers with installation data and instructions for C&N-developed equipment used in their aircraft. This branch is the lab's principal liaison with mockup boards and joint project officers.

One of three sections in the branch, Liaison & Design, is staffed by engineers who are essentially equipment specialists

The other two sections, Bomber & Missiles, and Fighter & Transport, have men who are specialists in their particular type of airframe, knowing its installation problems and limitations

▶ **Special Lab Facilities**—Recognizing the expense and difficulties of flight testing, the C&N lab tries to do as much as possible of its testing on the ground. This requires many specialized test facilities, such as

- **Noise room,** for testing understandability of aircraft mikes, headsets, and interphone systems, electronically simulates engine, propeller, and aerodynamic noises
- **Personal altitude chamber,** which can also produce simulated cockpit noise, is used to test understandability of communications equipment under altitude conditions
- **Anechoic chamber,** constructed so as to eliminate reflection of sound waves from chamber walls, is used in acoustical measurements
- **Million-volt** generator is used for corona discharge tests to evaluate interference rejection of communications equipment. At lower voltages, the generator is used to determine the radio noise and discharge current characteristics of static dischargers or corona onset voltages for corona-resistant antenna assemblies
- **Flight simulator,** which can be used to evaluate new types of navigational cockpit displays
- **Ultrasonic trainer,** which simulates motion of an aircraft over land, is used in evaluating human engineering aspects of navigational radar design



SEARCH for better components requires research into fundamentals of their operation.

ECL's Field: Avionic Components

Dayton—The Electronic Components lab is testing a new line of ceramic vacuum tubes capable of operating at ambient temperatures of 250C despite the fact that most avionic equipments today need only operate at 100-125C. This is ECL's job—to anticipate the component needs of the avionic equipment designer and to sponsor or stimulate research programs that will make these components available when needed, according to Col R S Carter, chief of ECL.

▶ **The Catalyst**—Airplane and missile speeds and operating altitudes are continually increasing, forcing equipment designers to seek higher temperature, more rugged components But the components won't be available unless the component manufacturer has started his research 2-3 years previously The Electronic Components lab serves as a catalyst to get component manufacturers started before the need would otherwise be apparent

This is particularly true of avionic components whose requirements are so stiff that they find little application in commercial or industrial electronic fields

ECL works closely with other Air Research and Development Command labs to find out what their needs will be during the coming years What sort of radar peak powers and new operating frequencies are envisioned, for example. ECL then sponsors development or research in the component industry or in universities to meet these needs

Sometimes the goal is improved performance or higher operating temperature Sometimes the object is smaller size or lower weight Or the program can be pointed toward new manufacturing techniques to permit automatic production of components now fabricated largely by hand operations, as is the case with vacuum tubes

▶ **The End Product**—The result or end

product of ECL research and development programs is technical know-how, according to H. V Noble, ECL's technical director

This knowledge is converted into a component specification and made available to the various component manufacturers

In many cases, manufacturers carry the ball from here, tooling up and getting into production on their own, Noble says If the potential market for the device is extremely limited, the Air Materiel Command, through its industrial mobilization group, awards a contract to one or more manufacturers to cover initial tooling and pilot production

▶ **Lab Organization**—To handle its assigned mission, ECL has approximately 200 people on its staff, of whom about 60% are engineers or scientists, Noble says Annual R&D expenditure runs about $3-5 million

The lab itself is divided into four Branches

- **Components Development**, under F E Wenger
- **Components Test**, under D L Lane
- **Electron Tube**, under A H Dicke.
- **General Puspose Test Equipment**, under N D Flinn

Components Development

Development of all avionic components, from radomes to tube sockets, to pilot lights to shock mounts (but not vacuum tubes and transistors) is assigned to the Components Development branch Its activities include research into automation techniques for completely automatic fabrication of avionic assemblies and new ways to disseminate information on available components

The Branch is divided into five sections

- **Dielectrics**, under Fred Behrens
- **Resistance, Inductance, & Capacitance**, under C E Doyle
- **Mechanical**, under C A Golueke.
- **Electromechanical**, under I S Mayer
- **General Engineering**, under Yale Jacobs

▶ **Dielectrics Section**—Radomes (radar antenna covers) of the future will probably be made out of ceramic or other inorganic material capable of withstanding the extremely high temperatures encountered in ultra-high speed flight, according to Fred Behrens, chief of the Dielectrics section

Increasing airplane speeds have created a progression of radome design problems for this section in the past and will continue to in the future.

When jet interceptors first started using radar, airplane designers complained that a hemispheric-shaped radome ruined the aerodynamics of the airplane, but streamlining the radome spoiled its "optical" characteristics (Ideally a radome should in no way affect the radar energy passing through it)

Streamlined radomes caused refraction of the radar beam creating distortion not unlike that experienced in the curved portions of automobile windshields Also, some radar energy was reflected internally, bouncing around inside the radome to cancel outgoing radar energy and creating spurious targets on the radar scope.

ECL-sponsored programs have developed new techniques for designing and fabricating radomes which have partially solved these problems, Behrens says The use of several different dielectric materials in radome construction, and the close control of radome thickness has greatly reduced internal reflections

Whereas transmission efficiencies used to vary as much as 20% from one portion of a radome to another, this figure has been cut to only a few per cent, according to Behrens Refraction

Every B-36 lands on U·S·S Carilloy Steel

● When 179 tons of B-36 thump down on a landing strip, tremendous stresses are built up in the structural parts of the landing gear. Only the highest quality in steel can handle this tough job, which is one of the most exacting in the aircraft industry.

All of the rugged main columns for these landing gears are made from U·S·S CARILLOY electric-furnace aircraft quality ingots. This high quality alloy steel provides the great strength and shock resistance demanded in the performance of the finished part. The main columns for these landing gears are forged. The original ingot, as shipped to the forger, weighs approximately 37,500 lbs. From it are produced two columns each weighing about 1200 lbs. In other words, approximately 93% of the steel has been removed—with a mere 7% of the original ingot left to do this tremendous job. Obviously, this steel must be of the very best quality.

The same care and skill go into every ton of U·S·S CARILLOY steel that *you* buy, whether it's a giant alloy ingot or a few tons of special steel. Our experienced metallurgists keep a close check on *every* heat of steel to make sure it has the strength, hardness, toughness and machinability that's needed.

If you have a special steel problem, let us know. We'll be glad to help you with it.

U·S·S CARILLOY electric-furnace aircraft quality steel meets every requirement for these vital parts. The precision machining and expert heat treatment they get at Cleveland Pneumatic Tool Company complete the job.

NO ORDINARY STEEL could withstand the huge shock loads imposed on the main landing gears of Convair's giant Air Force B-36 Bomber. The plane has a maximum gross weight of 358,000 lbs., with still higher landing shock loads. U·S·S CARILLOY steel has more than enough impact strength to hold up under this severe punishment.

UNITED STATES STEEL CORPORATION, PITTSBURGH · COLUMBIA GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
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(boresight) errors have been reduced, but there is still room for further improvement, Behrens notes.

▶ **Protection From Rain**—In the past, raindrops beating against a radome on a speedy airplane frequently caused the radome to disintegrate. The Dielectrics section has developed a protective coating for radomes which enables them to stand up under moderate rainfall for several hundred hours in high speed jet planes.

Although aircraft manufactures now design their own radomes, the Dielectrics section does the pioneering work on fundamentally new designs. For example, it has several development contracts under way to devise new inorganic radome materials for ultra-high-speed flight. This section also prepares performance specs which aircraft manufacturers can follow in designing their radomes.

▶ **New Sub-Min Connectors**—The Dielectrics section expects to establish a new standard sub-miniature connector, for use in low-voltage, low-current circuits, during the coming year, Behrens says. This is based on a study of WADC electronic equipment which showed that 90% of their connector pins carry "only a few milliamps of current at a couple hundred volts." This makes it possible to use smaller pins, more closely spaced, to cut size and weight, Behrens reports.

As presently envisioned, the new line of sub-min connectors will be used for the majority of the incoming circuits, the high voltage and high-current circuits will feed through the larger, conventional connectors.

The Dielectrics section is sponsoring the development of several sub-min connectors and expects to evaluate these and others, developed with private funds, within the year to establish the new AF standard.

▶ **Waveguides Too**—New techniques for fabricating waveguides to use less critical materials and reduce weight have also come out of the Dielectrics section. One technique uses a steel-cladded material which is formed in a rolling process, and thus adapted to mass production techniques. The result is a waveguide which weighs only one-fifth as much as a brass waveguide and is considerably less expensive to produce.

When the Aircraft Radiation lab is contemplating a new operating frequency for radar, it turns to the Dielectrics section here to develop suitable waveguide and transmission line components for the new frequency.

▶ **Ohms, Henries, & Farads**—Variable inductors using ferrite cores appear likely to replace variable condensers for tuning purposes in future transistorized equipments, according to C. E. Doyle, chief of the Resistance, Inductance & Capacitance section, unless someone devises a new way to sub-miniaturize tuning condensers. Development of tiny components for use in transistor circuits is a major program in this section. Unless sub-miniature components are available, "transistorizing" won't reduce equipment size greatly.

Because transistors operate at lower voltages than vacuum tubes, fixed capacitors are being redesigned for use at lower voltages (1-50 v.). The lower voltage would ordinarily permit the use of thinner dielectric materials, except that they are already so thin that physical strength rather than dielectric strength is the limiting factor. To get notable reductions in the size of fixed and variable capacitors, "we need some radically new techniques," Doyle remarks.

He reports that one manufacturer now is at work on a "markedly different technique" of making capacitors. The program is privately financed, and reportedly shows a promise of cutting paper capacitors to one-tenth their present size, and electrolytics to perhaps half their present size. End products of this program are several years away, Doyle believes.

▶ **Film Resistors & Pots**—Film type precision potentiometers with the same accuracy as present-day wire wound pots should be available in several years and at a considerably lower price, it is estimated. The film technique is particularly well suited to making non-linear potentiometers, and it avoids the use of critical materials.

Another promising resistance film, which shows practically zero temperature coefficient characteristics, is under investigation at the Battelle Memorial Institute. This film can be used in making both fixed resistors and pots, Doyle says.

A few of the other investigations that are being sponsored by this section include:

- **Transformers and coils**, for use in transistor circuits (Radio Corp. of America).
- **Non-metallic magnetics**, including such materials as ferrites, are under study at General Electric to find possible new applications and uses.
- **Magnetic amplifiers** and new magnetic materials to improve the response of mag-amplifiers.

▶ **Mechanical Section**—A modular type case for housing avionic equipment, and a rack in which these cases are compactly stacked to fit the curvature of an airplane fuselage, have recently been developed by the Mechanical section, headed by C. A. Golueke. Several new AF equipments are going to use

the new case and rack configuration and, if it proves successful there, it could become mandatory for all AF avionic equipments

The new system gives the equipment manufacturer a wider selection of case sizes He has a choice of three controlled widths (5, 11¾ or 17¾ in), uncontrolled case length to 9 in. and fixed beyond that at 12, 16, and 20 in , and a choice of heights varying in ⅞ in increments Pressurized cylindrical cases are accommodated by mounting them on a rectangular front panel and supporting cradle.

Shock and vibration mounts for individual cases are eliminated in favor of isolation mounts for the entire equipment rack. This permits cases to be mounted flush to one another, eliminating "sway space" normally allocated when each has its own isolation mounts Equipment cases of varying lengths can be positioned in the rack in a "stair step" arrangement to conform to the contour of the airplane fuselage

Specifications for the new standard cases, MIL-C 7452 (USAF), were issued this spring, the rack spec, MIL-R 7453 (USAF) was released only during the past month

▶ **Shock and Vibration**—The Mechanical section concerns itself with other mechanical aspects of avionic equipment design

For example, the mounting bases of avionic equipment chassis are usually beefed up to be sure they won't tear loose in a crash and become a flying hazard to the crew This section is developing shock links which will be used to anchor equipment to the rack, yet designed to yield sufficiently to dissipate crash momentum This will permit the use of lighter chassis for all equipment, Golucke says Working models of the new shock link are expected in nine months

This section also has studies under way to measure the general level of vibration and shock that exists in different portions of present day aircraft and missiles

Concurrently another program is determining the general level of shock and vibration which different types of components (tubes, relays, transformers, etc) can withstand without failure The end product is expected to be a designers handbook aimed at guiding engineers in the mechanical design and layout of avionic equipment

▶ **Electromechanical Section**—A new tube socket which will permit all the internal wiring of an avionic assembly to be hermetically sealed, while its tubes protrude into the outside area where they can better dissipate their heat, is a recent product of the Electromechani

cal section. These hermetically sealed sockets are expected to be available in seven- and nine-pin miniature and in octal bases within three to six months, according to I. S. Mayer, section chief.

This section is responsible for a variety of components, from tube bases to circuit breakers, from metallic-plate rectifiers to rotating shaft seals, from small panel meters to pilot lights.

▶ **High-Temp Rectifier**—Rectifiers made from titanium dioxide appear to be capable of operation at temperatures as high as 200C, considerably beyond the limit on present selenium rectifiers, Mayer reports. The new titanium dioxide rectifiers also appear to have high back impedance, low forward impedance, and to maintain their characteristics with temperature and age. This makes them extremely attractive for use with magnetic amplifiers, Mayer notes.

The trend toward building test circuits and devices into avionic subassemblies to permit operators or maintenance men quickly to spot a bad unit, should get a boost from a tiny microammeter developed for this section. Only one inch in diameter, the meter has a 270 degree scale which gives excellent readability despite its small size. The device was built by International Instruments Inc. of New Haven, Conn.

▶ **General Engineering Section**—The vastly increased use of avionics in aircraft and missiles has prompted many to wonder whether this country could produce enough avionics to sustain a full scale shooting war. The problem is particularly acute because of the large amount of hand labor involved in present fabrication methods.

This explains why the General Engineering section has launched a program at Stanford Research Institute to develop techniques and machines for producing avionics devices automatically and with practically no hand operations.

The Army Signal Corps and Navy have somewhat similar programs under way, according to Yale Jacobs, section chief, but he says that the project is so important that "many heads are needed to investigate all possible approaches."

▶ **Two Tasks**—One of the General Engineering section's major tasks is to foster and develop new avionic fabrication techniques, including miniaturization, cooling and automatic production. The other task is to devise ways for quickly supplying equipment manufacturers with information on the availability of components they need.

In fostering new fabrication techniques, the section operates in several ways. On the problem of designing adequate cooling provisions into avionic equipment, the section has established

Ohio State University as a research center in this field Each year, ECL and Ohio State sponsor a 2 day conference on avionic cooling problems which is well attended by engineers from aircraft and equipment manufacturers

Another approach was used when a contract was given to Lear, Inc., to miniaturize the old World War II BC-348R radio receiver (200 kc to 18 mc.) Lear made no attempt to improve the set performance, tried only to cut size and weight. The result was a set weighing only one-third as much and only one fifth as big

Reports on projects like these, with emphasis on the techniques employed, are then circulated to industry and WADC project engineers for application to new equipments Jacobs says

▶**Component Information Center**—A centralized source of information capable of providing the names of manufacturers who can supply any desired component is envisioned as the result of a study by the Battelle Memorial Institute

If an engineer wants to find out who manufactures the smallest two-phase 400-cycle, 1/100-hp induction motor the request would be submitted to the Electronic Components Information Center (ECIC) where machines would sort through thousands of punch-cards to get the answer

Another similar program at Battelle is the preparation of an Electronic Components Development Register which lists new experimental components under government-sponsored development and the date when they are likely to be available If funds permit Jacobs says that ECL plans to publish this register every six months

Another project is to publish planning charts for component manufacturers to show areas where new component developments are needed

Components Test

New devices produced in the Components Development branch undergo test and evaluation in the Components Test branch

Test facilities include the normal complement of environmental test chambers (altitude temperature, humidity) plus microwave test devices for measuring the transmission characteristics of radomes and radome materials

Other facilities permit the measurement of dielectric constant and loss tangent of dielectric materials up to 8,600 mc. over a temperature range of −65C to 300C

The branch is divided into six sections four of which are directly assigned to test the products of their counter

parts in the Components Development branch

- **Dielectric Test**, under M W Miller.
- **Resistance, Inductance & Capacitance Test**, under J F Rippin
- **Mechanical Test**, under C. W McDowell
- **Electromechanical Test**, under W E. Deis
- **Atmospheric**, under J C Wightman, carries out environmental tests for the other sections
- **Calibration & Standards**, under R W. Stolzenbach, is the "little National Bureau of Standards" for the Air Force. It provides calibration facilities for instruments used in all other WADC labs, and coordinates such work for all other ARDC centers

Electron Tubes

In the fall of 1950, the Strategic Air Command reported that roughly half of its aborted missions were caused by failures of electron tubes. This illustrates the importance of developing tubes specifically designed to withstand the rigors of the airborne environment—the assignment of the Electron Tube branch.

The branch is divided into six sections

- **Transistor**, under R D Larson
- **Receiving Tube**, under L L Cibbs
- **Special Tube**, under W H Nelson
- **Transmitting Tube**, under J R Hayes
- **Tube Techniques**, under Dr O M Stuetzer
- **Tube Test**, under S Badger

▶ **Transistor Section**—Development of transistors capable of operating at the high temperatures encountered in airborne use is one of the programs under way in the Transistor section

Silicon looks promising as a high-temperature transistor material, Larson reports, but it is difficult to produce in the required degree of purity.

Another project is aimed at improving transistor reliability and the contractor is reported to be making good progress. Hermetic sealing appears to solve the reliability problem for grown-junction transistors, Larson says, and he adds that all manufacturers are going to hermetic sealing.

Asked about power transistors, Larson reports that an undisclosed manufacturer has demonstrated a transistor capable of handling 40 watts, and he adds that transistors capable of power outputs of one to five watts should be in pilot production by the end of the year.

Larson also reports that a manufacturer expects to have germanium diodes capable of handling up to 50 amperes, a 500 fold increase over the present top rating of about 100 ma. Larson also noted a trend to four element (tetrode) transistors to achieve improved operation at higher frequencies

▶ **Receiving Tube Section**—There is a two-pronged program under way in the Receiving Tube section to get better and more reliable tubes.

One, an interim program, employs more rigid specifications, inspection, and test, to maintain improved quality control on existing tube designs. This program, known as the 6000/CT series tubes, or Military Control Electron tubes, has resulted in much more reliable tubes, based on limited experience to date, according to L L Cibbs, section chief. When sufficient quantities of the MCET units are available, they will be recommended for use in all AF equipment, Cibbs indicates.

The second phase of the program is a long-range effort involving fundamental changes in tube design and construction—for example, the use of ceramic envelopes instead of glass.

Another objective is to design the tube so it can be constructed largely from pieces that can be punched or drawn on automatic machines, eliminating most or all manual operations. This is expected to produce more reliable tubes.

▶ **New Ceramic Tubes**—Raytheon Mfg Co. has developed a ceramic tube equivalent of the 6L6 beam power tube which can be operated at a temperature of 250C without derating. The new tube is only 1/5th the size of a conventional metal 6L6 which is only rated for operation at 70C

Cibbs says Raytheon is developing three other ceramic tube types using similar construction: one is a video amplifier, another is a half wave rectifier, and the third is a low mu triode.

The tubes' compact construction and the use of ceramics should make them extremely rugged, Cibbs believes. He says they are still in the developmental stage and not ready for production

▶ **Transmitting Tube Section**—There has been a sizable improvement in the frequency stability of some magnetrons (used in airborne radars) as the result of development programs sponsored by the Transmitting Tube section, according to E. L Breen. The careful selection of materials used in constructing magnetrons prevents changes in physical size of the cavity due to temperature changes, giving improved stability.

Breen also notes similar improvements in the stability of reflex klystrons, making them relatively unaffected by temperature and altitude changes.

▶ **Special Tube Section**—Cathode ray (electron beam) tubes and thyratrons are the major concern of the Special Tube section

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A recent development is a very high intensity direct view storage tube which can be used to display visual instructions transmitted from the ground, or could be used in a radar scope. The tube, developed by RCA, produces a "blinding" illumination of 5,000 foot lamberts, according to W H Nelson, section chief. This section has recently launched a program to develop a long persistence color CRT

Two recent developments may find widespread use as built-in fault-indicators for avionic sub-assemblies. One is a tiny cathode ray tube (1 in. dia x 3 in. long) which can display significant waveshapes. The other is a tiny "magic eye" tube (3/4 in. dia x 1 in. long) which has two voltage indicators capable of giving an approximate indication of voltage magnitude without disturbing high impedance circuits

▶ **Tube Techniques Section**—Applied research into the physics and chemistry behind transistor and vacuum tube operation is done in the Tube Techniques section under Dr O M Stuetzer

In the course of this work Dr Stuetzer invented the "fieldistor," a type of transistor in which the input signal controls output by means of an electrostatic field

Advantage of the fieldistor is its desirable high input impedance; disadvantage is the difficult fabrication technique involved in its construction.

▶ **Tube Test Section**—Newly developed transistors and tubes are put through their paces in the Tube Test section, which serves the other sections in this branch much like the Components Test branch serves the Components Development branch

This section is equipped with latest test equipment for evaluating transistor performance, including noise, impedance, four pole parameter, rise, fall and delay time

General Purpose Test Equipment

The General Purpose Test Equipment branch is divided into three sections, with these responsibilities

- **Development**. General purpose test equipment such as ammeters, ohmmeters, multimeters, vacuum-tube, voltmeters
- **Measurements & Techniques**. Develops new measurement techniques to permit the use of simpler, less expensive test equipment
- **Interference Reduction**. Develops new techniques for inter-equipment interference reduction and establishes tolerable limits of radiation from individual equipments developed by all other WADC laboratories

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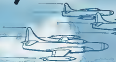

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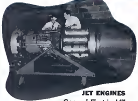

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WADC's Armament Laboratory:

Where Avionics Joins Firepower

Dayton, Ohio—It was little more than 10 years ago that a group of high-ranking Air Force officers visited the General Electric plant in Schenectady to see a demonstration of the then radically new remote-control turret system to be used on the B-29. The officers were quite impressed to see two large twin-gun turrets being remotely positioned from a small gunsight 40 feet away.

Then one of the generals walked over to look inside one of the system's black boxes. His jaw dropped as he counted 12 vacuum tubes. What he said as he walked away left little doubt that he thought that vacuum tubes had no place in aircraft armament.

Today, WADC's Armament Laboratory might well be called the Electronic Warfare Lab, if that name had not earlier been applied to electronic countermeasures groups elsewhere.

In 10 short years, the vacuum tube has become the backbone of aircraft armament. But there is a growing awareness here that avionics can not do it single-handed, that these complex avionic armament systems must be designed to accommodate better the human operator who must use them and the men who maintain them.

▶ **Bombing Accuracy Up**—Despite the fact that bombing accuracy tends to deteriorate as bomber speeds and altitudes increase, we are now achieving better radar bombing accuracy in any weather than we got at World War II speeds and altitudes by optical means, according to Lt. Col. S. C. Phillips, chief of the Plans Office in the Armament lab. Major credit goes to the new K-series (radar and optical) bombing and navigation system. One version of this system reportedly weighs 1,700 lb. and uses 365 vacuum tubes.

Not all of this complexity can be charged solely to increased bombing accuracy. In our new B-47 jet bombers, a three-man crew performs the tasks that kept 11 men busy in World War II B-29s. For example, a single B-47 crewman serves as bombardier, navigator, and radar operator.

This requires the K-system to perform automatically many of the functions performed manually on previous bombing systems, and this means more complexity, according to Lt. Col. W. M. Hilt, chief of the Strategic Bombing branch.

▶ **No End in Sight**—As bomber speeds go even higher, bombing and navigation systems will become even more complex, Hilt predicts. More automaticity will be needed because human reaction time can't be speeded up to match higher bomber speeds.

With increased bomber speed, the bomb must be released farther away from the target so the bombing system must be able to "acquire" the target farther out, Phillips says.

New-type bombing systems, which will permit bombing without using any target-derived data, are under development, Phillips says.

▶ **Lessons From the Past**—The evolution from simple optical bombsights to complex avionic bombing systems has been a difficult one and the Armament lab is trying to apply the painfully learned lessons of the past to its new bombing systems. For example:

• **System Engineering**. When radar was first applied to airborne armament late in World War II, it proved expedient to "marry" the radar to existing armament by means of adaptors ("marriage boxes").

Experience showed that these complex sub-systems were not easily mated. The Armament lab found that it didn't have sufficient manpower or facilities to handle systems-engineering on large complex systems.

Present practice is to give complete system responsibility to a single prime contractor. This assures optimum system integration and minimum system weight and volume, according to P. E. Koenig, technical director of the Armament lab.

• **The Human Factor**. As the requirements for weapons systems performance increase, it becomes necessary to pay more attention to the relationship between the man and his equipment.

The Air Force has learned that operations which are easy to perform during a training flight may prove unnatural and difficult under the strain of combat conditions.

For example, radar scope data should be presented to the bombardier in a natural or familiar fashion. These principles are being applied to new bombing system designs, according to both Phillips and Hilt.

• **Reliability**. In 1950, the Air Force was experiencing a large number of aborted training missions and many of these were charged to vacuum tube or avionic equipment failures. Unreliability is one consequence of increased complexity, at least in the early stages of equipment design.

Project Reliable was formed in 1951 to find the basic causes of armament system unreliability, to clean them up, and to project that knowledge into future designs. (One phase of this program was to produce more reliable vacuum tubes which the Electronic Components Lab has achieved through

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its Military Control Electron Tube program

Project Reliable lessons are being applied to new bombing systems, Hilt says. These will have "go, no-go" type testers built in to enable the bombardier to check out his system in flight. If he finds a malfunction, he can isolate it by switching to another mode of operation, in many instances.

The system is being designed using highly "unitized" construction, to permit quick replacement of faulty units. Improved ground maintenance testers have been developed to expedite system test and trouble shooting, Hilt adds.

▶ **Avionic Impact On Fighters**—For many years fighter armament consisted of guns and a simple ring-and-bead sight, but avionics has changed all that, with impressive results. Sizable credit for the overwhelming Sabre-to-MiG kill ratio in Korea (which from May to the end of June was 74 MiGs, zero Sabres) is given to the computing gunsight, and its companion range radar, by Lt. Col. G. C. Clementson, chief of the Fixed Gunnery branch.

Although much has been written in praise of the computing gunsight, Col. Clementson emphasizes the important role of the range radar set which measures the distance to the target and feeds this information into the computing gunsight.

The gunsight computes the angle by which the Sabre guns must be aimed ahead of the target's present position. This "lead angle" is the product of target velocity and (essentially) target range. Thus a 10% error in range information means roughly a 10% error in lead angle computation—enough to completely miss the target.

▶ **Importance of Range Radar**—Before the advent of range radar, the pilot had to turn a small knob to adjust the diameter of a circle of dots in his gunsight so that they continuously spanned the target. He had to do this in the heat of combat while he was simultaneously trying to maneuver his plane into position, adjust engine power, and anything else that might come up. The result was very inaccurate range data for the gunsight computer, and poor tracking, giving incorrect lead angle computations.

With range radar, the pilot can concentrate on tracking his target while the radar continuously pumps accurate range data into the gunsight computer.

▶ **Aware of Complexity Dangers**—Clementson shows a keen awareness of the dangers of going overboard in fighter armament complexity. For example he told Aviation Week that his branch is currently analyzing two new fighter gunsights to determine which should go into production as a replacement for the sight now in use. One of the new sights is considerably more complex but will give improved accuracy, providing that the fighter pilot is able to track his target very smoothly. But in the newer highspeed fighters, airplane stability is not as good as in slower aircraft, making it difficult to track smoothly, Clementson says.

The other new gunsight under consideration has accuracy "comparable" to the gunsight now in use, but it is fundamentally much more simple in construction and should therefore be easier to maintain and keep in operation, Clementson says.

In weighing these two new gunsights, Clementson says that the more complex sight could be as reliable as the simpler one, after a suitable period of equipment "debugging" and personnel familiarization.

The trouble is this: if the "debugging" and familiarization period is too prolonged, the equipment will be blacklisted, or obsolete before an acceptable degree of reliability is achieved, Clementson says.

▶ **Interceptor Fire Control**—Interceptor fire control systems, developed by Hughes Aircraft and currently in use on the F-86D, F-94C, and F-89D, have increased the probability of locating and destroying an enemy bomber by a factor of 10:1, Clementson estimates.

This ratio is based on comparison with airplane capability if it had no airborne fire-control system and had to be directed by ground controlled intercept (GCI) radar.

Present interceptor radar fire-control systems enable the pilot to spot a target in any weather. A computer automatically calculates the required interceptor course, and in some versions, the autopilot automatically maneuvers the airplane into the correct position and holds it on the calculated course.

More advanced systems under way at Hughes will fire the Hughes-developed Falcon air-to-air missile. This is expected to increase the probability of successful interception considerably, Clementson says. For one thing, it will enable the interceptor to open fire at greater distances from the target, making it less vulnerable to enemy bomber counterfire.

▶ **Bomber Defense**—Bomber defense, for which the vacuum tube was first introduced into the armament field, has been hard hit by recent avionic advances. The new automatic interceptor fire-control systems and guided missiles pose a serious threat to bomber defense, according to Major E. O. Godfrey, chief of the Bomber Defense branch.

It would be possible to provide extremely good bomber-defense capabilities, Godfrey says, if space and weight were no limitation. However, he points out that fuel tanks usurp most of the space in new jet bombers, leaving little room for turrets or gunners.

Bomber defense tends to take a back seat to greater bombload, longer range, and better bombing systems, until the crew finds itself under attack," Godfrey notes.

▶ **ECM Will Help**—A few years ago, many people held a defeatist attitude on bomber defense, Godfrey says, but there have been recent developments which show considerable potential. Electronic countermeasures, for one, appears to offer "tremendous possibilities," Godfrey says.

The use of long-range radar to spot and track enemy fighters much farther out is another answer to the problem of higher closing speeds in jet combat, he notes.

▶ **Tactical Bombing Branch**—Shoran equipment, used in tactical bombing for target location, is an exception to the general rule that Rome Air Development Center handles ground-based avionics. The Tactical Bombing branch here is responsible for both the airborne receivers and the ground-based beacons.

This branch is charged with developing bombing systems for both fighter-bombers and tactical (medium) bombers, to enable them to knock out anything from a railroad marshalling yard to a truck, from a radar site to a railroad

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bridge, or from supply dumps to troop concentrations

The Tactical Bombing branch works very closely with RADC on the TAC weapons system program. Despite occasional differences of opinion on the best approach, A. Zmeskal, assistant branch chief, says that good progress is being made toward improving the interdiction capabilities of tactical aircraft.

► **Disappearing Autopilots**—Automatic pilots, as such, may cease to exist. This startling statement comes from Col. A. I. Lingard, head of the Automatic Flight Control branch which is responsible for autopilots, stability dampers, and similar devices. At first blush this might indicate that autopilots no longer serve a useful military purpose, but the situation is actually just the reverse.

Automatic pilots have become so important to bombing systems and interceptor fire-control systems that the autopilot is being merged with the bombing or fire control system and thus losing its individual identity, Lingard explains.

In other cases the autopilot is being merged into the airframe because most highspeed aircraft need stability augmenters (damper systems) to make the plane stable enough for the human pilot to fly.

These stability augmenter systems are essentially autopilots minus heading gyros and attitude gyros, A. J. Longiaru, member of the branch points out.

► **Hydraulic Actuator**—Whereas the autopilot and the airplane's boost system formerly used separate actuators to operate the plane's control surfaces, a new hydraulic actuator has been designed which can be operated from either the pilot's stick movement or from electric "autopilot" signals, Longiaru says.

The small console-mounted control station which the human pilot used to introduce airplane maneuvers through the autopilot is giving way to a new type of control (pioneered by Minneapolis-Honeywell) where maneuvers are introduced by moving the airplane's regular control stick or column, Lingard says.

► **Techniques Branch** — A recently formed group in the Armament Laboratory is the Techniques branch which seeks out and explores new techniques which could find application in one of the other lab sections. This branch sponsors the development of new devices or sub-systems in the field of radar, infrared, computers, and optics, and evaluates their effectiveness for airborne armament.

This is intended to prove out new techniques before committing them to specific armament systems in the other branches.

Airman Survival Is Aero Med's Big Job

Dayton, Ohio—An aerosol bomb, a tight-fitting nylon suit and a can of rations have one common denominator—survival.

The bomb contains Aeroplast, a new spray-on surgical dressing for treating burns. It can be applied by anyone in minimum time and can save aircrew lives otherwise lost to fires in the air.

The suit is the T-1 partial-pressure protective garment. Already it has saved several extremely valuable test pilots and more than $18 million worth of aircraft they were flying.

The can is part of a survival kit for downed pilots and crew. The kit fits under the seat, and will shelter, feed and arm the crewman.

These are some of the items that are typical of the end product of research and development in aviation medicine, the primary job of the Aero Medical Laboratory.

▶ **Work Defined**—"We're concerned with basic and applied research in the human factors," said Col. Robert H. Blount, Chief of the laboratory at Wright Air Development Center.

"In military language, our mission is twofold:

- "To provide technical information based on scientific research.
- "To carry out the actual development of items of personal equipment.

"In less formal language, our job is to put a man in an airplane and to keep him alive."

How well is that job being done? Is the laboratory abreast of the aircraft performance required for the military tasks of the future?

"I believe we are keeping pace," said Lt. Col. C. C. Cain, who is Chief, Operations and Plans. "In one instance at least, we're ahead of the aircraft design. We try to get at the job about five years ahead of the time it will be needed."

▶ **Way Up High**—Cain told Aviation Week that it was Boeing's big B-29 Superfort that gave the first indications of human factors in aircraft design.

"It was the first plane we had that could go high enough on routine missions to introduce problems," he said.

"It was the first plane designed to provide a degree of comfort and efficiency for the aircrewman on routine missions.

"Temperature and pressurization for crew compartments, as well as improved crew workspace, indicated a realization of the human requirements on the part of the designers of that particular aircraft."

Cain pointed out that the inevitable design compromise is not new to aeromedical specialists. The requirements for high performance generally mean cutting down weight and cross-sectional area, and this makes the aeromedical job tough.

▶ **Information Lacking**—"One place where information is lacking," said Cain, "is on the number of missions during a combat tour where the pilot uses his emergency equipment. Also we don't have enough experience with combat at high altitudes to show the vulnerability of cockpit pressurization.

"Then there's one big problem. Do we make the aircraft and operator a combination to accomplish a mission, or do we want to use safety equipment to rescue the human operator? We don't have the answer to that one."

▶ **Recent Developments**—These are some of the development projects that have come out of Aeromed lab during the past months:

- **Resuscitator of extreme versatility.** This little unit can be connected anywhere that there is a low-power electrical source.

For example, at home, in aircraft, even in a car, where it can be plugged into the cigarette lighter. It produces positive and negative pressure, and will operate at altitude for use in combat or evacuation aircraft.

The unit is about as big as a man's fist and there is no supplemental equipment. Its development won for Henry Seeler the 1952 Thurman H. Bane award of the Institute of the Aeronautical Sciences.

- **Coordinated cockpit arrangement.** As one result of this continuing program, accidental raising of the landing gear on the ground has almost been eliminated. This used to be a prevalent accident because of confusion between flap selector and gear retraction lever.
- **Liquid oxygen converter.** This item rose out of the obvious space saving afforded by using liquid instead of gaseous oxygen. The Type A-3 Liquid Oxygen Converter is now a standard item scheduled for installation in the Republic F-84 series.
- **Minimum simulation for maximum effectiveness.** The high cost of flight simulators—approaching half that of the airplane itself—stems from the amount of simulation worked into the design of the trainers. But in some cases too much simulation has been found to reduce effectiveness in training.

One of the current jobs of Aeromed is to figure just how much simulation is necessary—or in other words, where is the point of diminishing return?

- **New anti-G suits.** There have been two new types of anti-G suits developed which raise the protection level about 3G above average tolerance, to an over-all level approaching 7G. One byproduct: G protection now approaches the values obtained by prone flight and poses the question of the practical value of the prone position in the plane from a physiological viewpoint.

Drag reduction requirements of supersonic flight may still necessitate flush cockpits, forcing use of the prone pilot position.

- **New inflight meals.** Aluminum foil packs are the basic idea behind a new scheme for inflight feeding of bomber and transport crews. A minimum of inflight preparation and expense can produce freshly cooked, nutritious meals.

Part of the same program is a new galley developed for MATS. It can be loaded aboard the aircraft by a lift truck, and comes in modular units so that several can be stored easily in a large plane. Service from the unit is expected to consist of sandwiches, soups and beverages.

- **Human Engineering Guide.** This is a document for designers where all available human engineering data will be assembled. The first complete volume is expected to be out in 1955, with portions available before then.
- **Handbook of Acoustic Noise Control.** This report is a general approach to the problem of noise, and gives contractors the best current methods for coping with the noise levels of new powerplants.

The scope of this work extends from design handbooks and reports to tangible hardware and food. Of all the survival projects that have gone through the lab, perhaps the most exciting to laymen would be the development of Aeroplast. To pilots and engineers, the protective clothing—typified by the

T-1 PRESSURE SUIT is high-altitude emergency garment with automatic operation.

1-1, V 3 and G suits—would probably be most interesting.

Here are detailed descriptions of these projects.

Aeroplast

Almost anyone can use an Aeroplast bomb. That is what sets it apart as a dressing for burns. The container has a thumb valve on top that sprays the burned area with a thin layer of plastic. That is the complete treatment.

The implications of such a dressing are enormous. In civil defense, for example, one of the chief worries is that there will not be enough bandage available to cover the hundreds of thousands of burn cases expected from atomic explosions.

▶ **Five-Minute Job**—But a 50% body burn—one in which half the skin has been seared—can be completely dressed by two medical corpsmen in five minutes, using four Aeroplast bombs. Compare that with the doctor and nurse, two and one half pounds of ointment, 120 yards of bandages and the hour or more required to treat the same burn by the current bandage technique.

Burns aren't the only type of injury that can be treated. Clinical tests were made of Aeroplast in Bellevue Hospital, New York, on skin-graft donor sites, operative wounds and lacerations as well as first to third degree burns. In most cases Aeroplast proved itself equal or superior to usual forms of dressings.

▶ **Development**—Aeroplast is the brainchild of Capt Daniel S. J. Choy. He began work in August 1951, developed the dressing, tested it, and wrote his final report by December 1952.

The material is elastic and flexible, waterproof and permeable to water vapor. It peels off easily, and does not leave the skin wrinkled or puckered.

It is inflammable, its base is chemically inert, but the solvent can be toxic in large concentrations. Only one out of a thousand control subjects showed any reaction to a patch test on the shaved forearm. In contrast, about 20% of the control group showed mild to severe reaction to the normal adhesive bandages used to cover the patch.

▶ **Bellevue Experience**—In any medical development, clinical testing is the final answer. Bellevue Hospital in New York used Aeroplast on a variety of cases, and it is worth citing a couple.

One patient was treated for first- and second-degree flash burns of the face, neck, trunk and arms. All the burns, except those on the face, were sprayed with Aeroplast. There was almost immediate relief of pain where the dressing had touched but the facial burns remained painful. First-degree

■ AERO-MEDICINE

burns were completely healed in six days.

Another patient had second-degree burns of fingers and hands from a gasoline fire. After spraying, he was encouraged to use his hands. He did, so vigorously that the plastic glove had to be retouched at the finger pads and web spaces. In 10 days, both hands were healed.

Current status of Aeroplast is one of waiting. it must qualify under the Pure Food and Drug Law, but this step is regarded as merely a matter of course by Aero Medical people. Following that, the plan is to make the dressing available to pharmaceutical houses for production to meet the needs of hospitals, the services and civil defense.

Pressure Suits

Valuable aircraft and more valuable pilots have been saved because of the pressure suit, developed after almost a decade of continuous work by the Aero Medical lab and universities.

"It's an emergency garment with automatic operation when cabin pressure fails," said Dr. Wayland Hull, physiologist with the lab. "It gives the pilot a strong second skin and—by mechanical pressure—supports his musculature and maintains normal circulation."

▶ **X-1 Started It**—The first high-altitude flights of the Bell X-1 touched off the need for the suit. Experimental units were borrowed from the lab for the flights, and the pilots, with some misgivings and some griping, wore them.

One day Lt. Col. Frank K. Everest was blasting along in the X-1 when his suit suddenly inflated. The cabin had been losing pressure steadily through a slow leak. When the cabin altitude reached something more than 40,000 ft., the suit inflated automatically. Everest was suddenly uncomfortable and somewhat inconvenienced, but he was alive. That convinced him, and similar incidents have made other pilots staunch believers in the suit.

▶ **Air Force Users**—Today more than 250 AF personnel are wearing one of two models of the suit.

- **Tactical and test pilots** get the T-1 suit, a combination of the emergency partial pressure garment and a G-suit.
- **Strategic crews** get an S-2 suit, which doesn't have the G protection—you don't pull many in maneuvering a big bomber.

The suits, originally custom tailored, are now available in a variety of sizes that will handle any Air Force pilot or crewman of normal build. A sergeant issues the suit, and makes initial

■ AERO-MEDICINE

adjustment of the many tapes which gives the final contours. Under pressure, an airman can't stand up straight, because the suit is adjusted to seated posture.

Leg and arm contours are distorted by external capstan tubes which run the length of the limbs. Tapes around these tubes tie in to the material of the suit. These tapes tighten the suit and apply pressure to the skin.

▶ **For Emergencies**—Normally nothing happens in the suit, said Dr. Hull, you don't need it unless there is an emergency at altitudes beginning somewhere above the 40,000-ft. level. The suit regulator is set to fire at 43,000 ft., when it goes off, it sends oxygen—from a bottle worn on the right side of the back next to the chute—through the capstan tubes and also into the helmet.

Under pressure, the capstan tubes expand and draw the tapes tight, that pressurizes your skin, and you're safe. There is a manual operator, just in case the automatic regulator doesn't work.

Next step is to fly the plane down to a safe altitude, disconnect the bottle and come home. If the plane is shot up or otherwise not worth taking back, you bail out in the prescribed way.

The suit holds pressure, the bottle contains about 10 minutes worth of oxygen for breathing and operation, and you can get all the way to the ground in that amount of time from any current altitude.

▶ **Development**—Many years of development work have been summed up in the T-1 and S-2 suits. Most of the early suit proposals were built around the full-pressure scheme of the diver's suit. Wiley Post had such a garment and an RAF officer wore one to set a world's altitude record in the 1930s.

Work on what was to be the T-1 suit started in 1943 and was greatly accelerated by the Air Materiel Command in 1946 as the flights of the X airplanes began.

Dr. Harold Lamport of Yale University was working with a scheme for exerting pressures in a G suit, using inflatable tubes with tension tapes to pull fabric tight. Dr. James Henry of Aero Medical had the idea of applying that system to pressurization of the whole body, and in 1946 delivered the first partial pressure suit to the Air Force.

Since then the suit has changed very little, although work continues on the development of an adequate helmet. In 1949 Air Force decided to standardize the suit, and in May this year, the last stages of that program were completed.

▶ **Two Pressures**—Although pressure is applied mechanically to the arms, legs and torso, the head and chest are pressurized pneumatically by pressure breathing, Hull explained. This is the reverse of normal breathing where exertion is used to inhale and the diaphragm relaxed to exhale. In pressure breathing, the oxygen is forced into the lungs as the airman relaxes, and exhaling is done forcibly.

Under pressure, the suit is uncomfortable but at an outside altitude of 40,000 ft., a pilot under pressure can squat, climb or touch the back of his head. At 50,000 ft. outside altitude, there is little inconvenience, the body reacts about as it does in free air at 10,000 ft.

The hands and feet, not covered by the suit, will swell if not protected. Special shoes and gloves are available to handle this situation.

V-3 Exposure Suit

Arctic exposure or the torrid cockpits of supersonic planes will not make any difference to a pilot wearing a V-3 suit. It is an air conditioned anti-ex-

■ AERO-MEDICINE

posure suit that protects him during immersion in anything from icy water to hot cabin air It is completely ventilated inside and uses high-efficiency insulation

Full Protection—With the V-3 suit, the pilot is fully protected against

- **Low temperatures to −70F.**
- **Cold water immersion**
- **Arctic exposure to −50F.**
- **High cabin air temperature to 160F.**
- **Cabin wall heat radiation to 350F.**

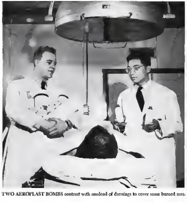
Explanations—How the suit is made and how it works were explained by John Hall, Jr, of the lab's physiology branch.

There are two pieces to put on—a spacer garment and an outer shell The spacer is made of Saran plastic woven into a loose netting It mounts ventilating tubes which run out along legs and arms, and distribute air on the basis of half the mass flow to the legs, and the other half divided between the arms and trunk, Hall pointed out

Over the spacer suit the pilot wears an impermeable outer shell which is basically the Navy's Mk 4 exposure suit This shell is lined with one-quarter-inch-thick wool pile insulation between waterproof layers of material You get into it through a cloth trunk which sprouts out of the neck, then you tuck in the trunk and zip up

▶ Valve Arrangement—The suit is bespangled with circular valves that are

V-3 Suit Spacer Garment



TWO AEROPLAST BOMBS contrast with armload of dressings to cover same burned area.

normally open But if the pilot sees himself headed for the water he pulls a wire which closes all the breather valves and seals them against water pressure. This arrangement is to be replaced by a refined valve that will be balanced to close and open under air loads and stay closed in water

The suit can be worn on the ground if you're willing to go through a calisthenic routine to make the suit act like a bellows and keep you ventilated For normal operation in an airplane, the suit can be hooked up to cabin air; this will work with high cabin air temperature because evaporative cooling can be comfortable

Ventilation can also be provided by a small (28-cfm.) blower If excessive temperatures plague pilots during the next decade, an expansion turbine should provide the answer

Anti-G Suit

An anti-G suit is a way to fool the heart The mechanism of this trickery has not been fully understood Dr O H Gauer, Dr J P Henry and their group of Aero Medical's biophysics branch, recently have evolved some new ideas on the operation of the anti G suit

▶ Different Aim—This new approach was not the original aim of Dr. Gauer. He was interested in a program of basic research on blood distribution in animals, part of his studies on the circulatory system in general

Key to the knowledge of suit operation was a tiny instrument with which Gauer and his associates were able to measure—for the first time—the extremely low pressures in the veins The instrument is a tiny manometer and transducer complete in a capsule not much larger than the top of a retractible ball-point pen

Earlier instruments used a pressure-sensing element inside the veins, then ran manometer tubes out through the skin to a remote indicator The trouble was that the pressures which had to be measured by this system were of the same magnitude as the errors in measurement

But the instrumentation developed for Gauer measures pressure and converts it to an electrical signal in the capsule itself, and there are no pressure losses to cope with as there would be in long lines

▶ G-Suit Action—In order to maintain the supply of blood to the brain under conditions of increased gravity load, the output pressure of the heart has to be increased With a G-suit, you mechanically compress the legs and the lower abdomen

The general explanation of the suit action has been that this compression

■ AERO-MEDICINE

tends to throttle portions of the arterial system and force the pressure to rise in other portions to feed the brain. This view is based on the tacit assumption that the heart is a constant-volume pump

▶ **Effect of Throttling**—Test have shown that the heart is a constant-pressure device, so if you throttle the system, Gauer says, the heart cuts down the output and there is no gain. What actually appears to happen is that by compression of legs and guts, pressure is raised on the input side of the pump—behind the left ventricle—and the heart adds its normal pressure rise to the inlet pressure provided by compression

The result is an outlet pressure sufficient to raise the blood to the head under high G

The extra blood from the compressed portions is pushed up through the veins and adds to the venous pressure. Extra volume of blood is stored in the lungs—a series of chest X rays show this fact clearly

The volume distribution of blood in the body is such that you cannot raise G protection indefinitely—there is a limit currently at 3G above the normal tolerance of 4C. There is also a limit to the amount of blood that can be squeezed into the lungs, and that amount is not enough to cause any damage

"This idea and work is one place where basic research has paid off," said one of the group's superiors "It was based on curiosity on how animals distribute the blood through their systems. Now we know how to design better G-suits"

Organization

Six branches perform the mission of the lab and support Wright Air Development Center in its over-all job Here is the task breakdown for the branches

- **Biophysics.** Study of flight acceleration affects, body-to-cockpit dimensional relationships, escape techniques and effects of noise and vibration
- **Clothing.** Design, development and standardization of all flights, functional and uniform clothing, some types of personal equipment and all restraining devices, establishment of material requirements for clothing
- **Engineering and development.** Design and development of oxygen masks and regulators, resuscitation equipment, survival kits, life rafts, medical and sanitation equipment, safety harnesses and the like
- **Physiology.** Response of humans to heat, cold, humidity, radiation, explosive decompression, study of vision, inflight and survival rations, and toxicology

V-3 SHELL is modified exposure suit.

- **Psychology.** Human engineering directed to improving the design of AF equipment for better operation, location, design and arrangement of instruments and controls, response tests and color for interiors
- **Service.** Design, drafting spec preparation, release, editing and distribution of reports, photographic work, maintenance and operation of the laboratory animal pens, and of air conditioning, refrigeration and altitude chamber facilities

The end product of these six branches is generally a technical report, sent out to the contractors who require the particular information

Facilities

As it stands today, the Aero medical lab calls seven buildings its permanent home, and lives in seven other barracks-type buildings and some space on loan from equipment lab Current floor space totals 77,328 sq ft

▶ **New Housing**—New buildings are either under construction or have been budgeted or proposed. Building 33, the newest lab building, is now being topped with a third floor to add 6,700 sq ft A high-altitude building is also under construction In final design stage are a new engineering building and an addition to the main building A bioacoustics facility is in the 1954 fiscal year budget request, and a clothing building will be sought later.

If all these buildings are approved, the lab's total space will be more than doubled to a total of 177,983 sq ft

▶ **Man vs. Machine**—Testing of humans is somewhat different from testing a

strip of stainless steel The testing machine has to be big enough to contain the subject and the equipment he is trying to operate or wear Consequently, Aeromed-lab facilities are big

The centrifuge, for example, is housed in a circular room more than 60 ft across It is made up of a pair of 48-ft-long steel booms that carry a free-swinging cab between them 20 ft from the spin axis Electric motors drive this carousel up to about 52 rpm. maximum —this would produce about 21G at the cab

Temperature in the cab can be controlled between 70F and 120F, and about 400 lb net is the load limit

Another man whirler is the spin table, an 8-ft-dia. horizontal centrifuge It is being used to study the effects of tumbling, the violent and unpredictable motion that occurs when a pilot ejects into the highspeed slipstream Volunteers have been whipped around up to 100 rpm while lying on their right sides with the body in a seated attitude

▶ **Ejection Tests**—Upward and downward ejection seat towers are another type of special test facilities used For upward ejection the test track rises 100 ft into the air, and the seat is stopped by gravity There are seven safety devices which work on three different principles to retain the seat Top speed—determined by the charge used to hurl the subject aloft—won't exceed 60 fps Acceleration peak is about 15G, with a rate of change of acceleration (now called "jolt") of about 150G per second

Riding the seat downward is somewhat different The seat is mounted 35 ft off the floor, and after ejection, roars into a curved section of track that guides the seat to a horizontal stop on a track section on the floor

▶ **For New Heights**—An altitude chamber was the first test facility at the lab, and since the early days, chambers have been added and modified to keep pace with the drive to higher and higher reaches

Col. R. L. Blount
Chief, Aero-Medical Lab

Latest of these arrangements uses a group of three interconnecting small rooms tied to a large 20 man unit The three chambers comprise a four-man, 225 cu ft chamber, an air lock, and a capsule with 60 cu ft capacity

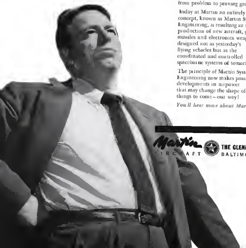
- **The four-man chamber** has an altitude capacity of 65,000 ft, and climb to altitude can be simulated at conventional rates, or by explosive decompression
- The air lock provides space for observers, and lets subjects be taken up or down without changing the simulated altitude of the test chamber
- **The capsule chamber** has one job higher altitude simulation than the group chamber Its small volume more nearly gives the decompression rate of a fighter cockpit suddenly depressurized by gunfire or failure Altitude capacity is 80,000 ft, still beyond the record for manned altitude flights

▶ **Crew Training**—One important job of the altitude chambers in this group is the indoctrination of test crews in the use of the partial-pressure emergency suit Other work which has stemmed from the use of these chambers includes the development of oxygen regulators and other protective equipment

The various units

- **Altitude chamber** for testing equipment has a completely removable back through which heavy units can be brought for test. The room is about 14 ft long by six feet wide and high Simulated rate of climb is 8,000 fpm to a peak altitude of 40,000 ft; temperature can be dropped to −67F
- Guardite stratosphere altitude cham-

Lt. Col. C. C Cain
Chief, Operations & Plans



ber is somewhat different and features precise control of altitude and temperature. The space, about 10 ft long, four feet wide and eight feet high, can be cooled from room temperature to −60F in four minutes after a precooling cycle

Pressure altitude and temperature control can be planned and coordinated through a time-schedule controller

• **All weather unit** is 13 ft wide, 18 ft long and 10 ft high Temperature can be set at any point between −40F and 160F, and held within about three degrees variation

• **Anechoic room** is the quietest spot in the lab It is used to study the effects of intense sound on animals and humans. Inside walls are lined with a foot and a half of Fiberglas faced with Fiberglas wedges one foot high and eight inches square on the base

• **Vibration table** rounds out the list This is a four by three foot steel plate that can be vibrated in three directions up to a frequency of 60 cps

How It All Began

Credit for the foundation of a separate medical service for aviation goes to the Germans In 1910 they drew up the first set of minimum physical requirements for pilots, and shortly after established the first aviation medical service

Another German idea was the program of pilot maintenance, based on medical reexamination at fixed intervals. This monitoring kept the physical standards of the Imperial German Air Service higher than any of its contemporaries

▶ **U S Recognition**—The U S was well into World War I before any formal recognition was given to the fact that flying demanded a new yardstick for physical examinations and requirements In September 1917, aviation medicine came into its proper niche when Gen. T C Lyster was appointed Chief Sur-

Dr. J. W. Heim
Chief, Physiology Branch

geon, Aviation Section, Signal Corps, United States Army

▶ **Lab Established**—Between wars, the awareness of medical problems related to the airplane and the new environment it imposed on humans came in for closer scrutiny by doctors in uniform One of these, Brig Gen Malcolm C Crow, is credited with the idea of founding a laboratory which would explore the physical effects of flight

Through Gen Grow's efforts, that laboratory was officially established in 1935 as the Physiological Research Unit, Experimental Engineering Section, Equipment Laboratory

First director of the lab was Capt Harry G, Armstrong, MC—now Surgeon General of the Air Force—who was picked for the spot by Gen Crow

▶ **First Home**—There was some available space in the basement of the Equipment lab which became office and lab for the fledgling unit Free balloons were going out of fashion then, and so a portion of the balloon hangar was turned over to the unit for installation of a centrifuge These unpretentious facilities were to be home—except for a few minor additions—until late in 1942

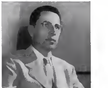
The job list grew and so did the personnel roster In 1939 there were so many different projects that the unit name was changed to Aero Medical Research Unit The next year, a detachment of Medical Department enlisted men was activated

▶ **New Status**—Next change was one of status From a unit, the aero-medical people were advanced to laboratory status, still under the Experimental Engineering Section, and Col Otis O Benson, Jr, was named chief

All this time the lab had been running out of space at an ever-increasing rate Brig Gen David N W Grant, then the Air Surgeon, appropriated money for construction of a new building about 100 by 50 ft, with three stories and a penthouse This new housing for the lab was completed in November 1942, and all activities, except for a small group working with altitude chambers, moved in

More money was forthcoming and was plugged into the construction of a human centrifuge and a building to house it In March 1943 the first spins were made and one month later the first human subject whirled through his gut-straining merry go round ride

That spring, the Aero Medical lab was presented with another responsibility—the development of oxygen equipment a job formerly assigned to the Equipment lab Lt Col W Randolph Lovelace, II, headed the new Oxygen Branch, and later that year was appointed chief of the entire lab



Dr H E Savely
Chief, Bio-Physics Branch

Currently, the lab is set up under the Directorate of Research at Wright Air Development Center, with Col Robert H Blount as its chief

▶ **Other Groups**—There are medical activities in the Air Force apart from those carried on here at WADC The USAF School of Aviation Medicine is one of these It was organized to train medical personnel in the peculiar requirements of aviation medicine, and has a secondary job of long-term and clinical research

There are medical organizations also at the AF Flight Test Center and at Holloman Air Development Center Both sections originated as part of the Aero-Medical lab, and were stationed in the field because of certain facilities available there They grew to size, and were made part of the Center's activities

The Future

There is still a lot of work to be done. Col Cain pointed out one of the areas—highspeed buffeting of aircraft—where little is known There is some feeling that this may present problems of fatigue and flying ability to pilots, and it must be studied

Good as the current suits are, work still continues on developments One goal a high-altitude suit for altitude protection of several hours' duration above 40,000 ft Another goal an all-zone flying suit to be worn anywhere pilots have to fly under global warfare

Oxygen systems still need perfecting—one project is aimed at the development of a simplified, lightweight and reliable system for the entire group of medium and high-altitude aircraft of the future

"We have to keep ahead of the field," says Cain "A man's environment and well-being is as important a part of the weapons systems as the guns he has to fire Our job is to anticipate future needs and keep man on a par with the functional reliability of the machines he flies"

Chute Facility Tests Unification

Testing parachutes is El Centro's big job; but joint AF-Navy operation also tests how services work together.

El Centro, Calif.—One of Air Research and Development Command's most unusual units, the Joint Parachute Test Facility, is operated jointly with the Navy and does 75% of its work for the Army

Located just north of the Mexican border on a Naval air station 41 ft. below sea level, the parachute group operates in the sweltering Imperial Valley area of California, more than 200 mi from its parent organization at Edwards AFB

Its mission is the development, testing and evaluation of parachutes and related devices But it is obvious that the facility is testing not only parachutes—it is testing unification

▶ **Cargo and Men**—"We drop cargo and men," is the way Col Leo C Moon one of the two commanding officers of the facility, describes activities at the test center He shares responsibility for the unit with Navy Cmdr William H Shockey

Both Air Force and Navy men tumble from high and medium-altitude aircraft to test equipment which later may save the lives of fliers in both services One Navy man has made 404 test jumps and several of the unit's personnel have jumped as much as eight times in one day

Majority of the projects, however, involve less dangerous cargo drops for Army testing, in which giant 200-ft chutes sometimes float to earth loads as heavy as an 18,000 lb bulldozer

"Give us an airplane big enough," says Col Moon, "and we can drop anything we can extract from the plane"

▶ **Chute Recovery**—In addition to testing personnel parachutes and aerial delivery systems for cargo, the unit also is concerned with parachute recovery systems for guided missiles deceleration parachutes for jet aircraft ejection seat parachute systems, and any vertical retardation devices which perform the function of a parachute These latter, so-called "roto-fins" have proved largely unsuccessful due to bearing problems, according to Col Moon

Live jumps are made in the level desert on the U S side of the Mexican border, 10 12 mi from the base, while small cargo and dummy drops take place on a 40 acre field just outside the air station Heavy cargo is tested in a more remote area and water drops are made into the nearby Salton Sea, largest inland body of water in California

Both Navy and Air Force aircraft such as R4Ds and C 119s, are assigned to the unit

▶ **Unit Chiefs**—Col Moon commands the Air Force's 6511th Parachute Development Test Group while Cmdr

CARGO CLUSTER chutes ease the drop of heavily loaded pallet in tests at El Centro.

Shockey's group is known as the Navy Parachute Unit (NPU)

The directive setting up the facility emanated from the Joint Chiefs of Staff. Technically, the unit reports to the Defense Department on its work but ARDC is charged with Air Force responsibility. Top-level reports are signed by both commanding officers, with one copy going to the Defense Department through ARDC channels while the other reaches the same destination through Navy BuAer channels. ARDC projects are assigned by the Wright Air Development Center.

The Navy unit works closely with the Bureau of Ordnance on such programs as mine laying by parachute and missile parachute work. Projects to test pod escape from high-altitude aircraft also are undertaken here. Navy has responsibility for Marine testing while Air Force takes charge of Army projects.

Certain of the unit's facilities, such as the instrumentation lab, whirl tower, drying tower, packing loft and fabric shop, are under Air Force operating control while the Navy takes charge of the windtunnel, textile lab, machine shop, metal shop and photo lab.

THREE PHASES in opening of new guide surface chute demonstrated by Navy and Air Force test jumpers.

WET LANDING completes parachute test.

► **Unification in Action**—Unification appears to work well on what Col. Moon calls "coordination on a personality basis." He and Cmdr. Shockey work closely to administer the facility.

Minor irritations can flare quickly into major disputes in a hot and remote location where temperatures as high as 120 deg. force the base to close down for the day at 2:30 each afternoon (work begins at 6 a. m. to take advantage of cooler morning hours). Individuals in either service who do not fit into the pattern are transferred quietly.

The Joint Parachute Test Facility is only one of several units on the El Centro Naval Auxiliary Air Station. Fleet Air Gunnery Unit (FAGU), for example, operates from the base on a mission similar to that of the Air Force gunnery school at Nellis AFB, Las Vegas.

The Naval base, under the command of Capt. Walter E. Premo, Jr., furnishes services for the facility, including food, housing and utilities. Air Force personnel are paid by the NAAS disbursing officer, who draws on a special fund.

Cooperation extends even beyond the operation of the parachute facility, with aircraft from Edwards AFB occasionally flying to El Centro to aid the Navy on missions unconnected with the parachute test work while Navy men sometimes assist on unrelated Air Force projects.

Perhaps the most revealing sign of this inter-service coperation is over the entrance to the coffee bar at El Centro. It reads "Unification Room."

ARDC Field Liasion Offices

A national system of field liaison offices is operated by the Air Research and Development Command to coordinate USAF technical projects and program and serve as a point of contact between USAF and persons who require technical information from the military.

The 22 field liaison offices in the development field organization are administered from ARDC headquarters in Baltimore. Following is the list of ARDC liaison offices:

■ Hq., Air Research & Development Command
Directorate of Field Liaison
Lt. Col. W. R. Beckett
Baltimore 3, Md.
Telephone: Lexington 2616
Ext. 44 or 344

■ Washington Air Force Development Field Office
Room 4945, Main Navy Building
Lt. Colonel H. A. Orban
Washington 25, D. C.
Telephone: Liberty 56700
Ext. 63594–62471

■ Air Force Development Field Representative
NACA Langley Aeronautical Laboratory
Langley Air Force Base, Va.
Telephone: Hampton 7911
Ext. 21144

■ Air Force Development Field Representative
Naval Research Laboratory
Maj. Edgar Van Rosen
Washington 25, D. C.
Telephone: Johnson 36600
Ext. 266

■ Air Force Development Field Representative
Applied Physics Laboratory
The Johns Hopkins University
Mr. H. C. Beaman
Silver Spring, Md.
Telephone: Washington—Juniper 97700
Ext. 10
Baltimore—Plaza 2 1317
Ext. 10

■ Air Force Development Field Representative
Engineer Research & Development Laboratories
Capt. Joe Sherman
Fort Belvoir, Va.
Telephone: Temple 67400
Ext. 34251

■ Air Force Development Field Representative
Army Field Forces Board No. 1
Maj. J. L. Hight

Fort Bragg, N C
Telephone Fayetteville 72311
Ext 38232

• Air Force Development Field Representative
Naval Air Test Center
Maj J E Foley
Patuxent River, Md
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Army Chemical Center
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Ext 4227

• Air Force Development Field Representative
Chemical Corps
Biological Laboratories
Camp Detrick
Lt Col W W Eakins
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Designs That Never Fly Play Important AF Role

A group of designers at Wright Air Development Center spends its time developing interesting new and radical aircraft designs that are never built—yet their work is reflected in production USAF airplanes of yesterday and today, and will be seen in aircraft and missiles of tomorrow.

It is their assignment to crystallize new potentials in power, and aerodynamics into designs which will give Air Force planners a definite fix on which route should be chosen to accomplish the missions planned. Often they develop several alternate designs for a single mission, and the actual production airplane may combine best features of each, or be a compromise.

Some of the design concepts pictured in model form are very recent, others go back several years. Included are: a turboprop light bomber, which looks like a relative of the Douglas XB-66 twin-jet light bomber; an early six-jet guppy bomber with common air intakes for engines buried in the plane's belly, and with common tailpipes, an early all-weather turboprop fighter fitted with three blade counter-rotating propellers of swept blade design, later obsoleted by very thin straight blades, an early pantabase fighter design with tandem retractible hydro-skis, a recent four-jet bomber design, with interesting notched sweepback in wing and a recent tailed delta fighter concept exploring the advantages of a conventional tail configuration with a delta wing.

NEWS OF THE WEEK

NEWS DIGEST

Domestic

Air Force Secretary Harold E Talbott said last week the U S will meet its commitments to NATO air power strength through this year and 1954 despite the $5 billion slash made by Congress in USAF's budget

North American RB-45 made the first nonstop jet flight across the Pacific, flying the great circle route July 29, 1952, from Elmendorf AFB, Alaska, to Yokota, Japan, in 9 hr 50 min, USAF disclosed Maj Louis H Carrington, pilot of the jet bomber, will be awarded the 1952 Mackay trophy for the "most meritorious flight" of the year

New flight director, designed to simplify ILS approaches, has been developed by Westinghouse Electric Corp and is being installed on an American Airlines Convair for evaluation New system adds a third pointer to the conventional ILS cockpit indicator to show rate of approach to the localizer beam center

Small business firms in the Los Angeles area have pooled their efforts by incorporating as United Western Manufacturers, Inc., Inglewood, Calif., to seek defense contracts in the metal trades industry The companies Air craft Div, Cahuenga, Inc, Certified Welders & Engineering Co; Hartford Manufacturing, Inc, Modern Plating Co, Telar Engineering, and Tubing Appliance Co

Pan American World Airways has replaced DC-4s and Constellations with DC-6Bs on Latin American tourist flights, cutting an estimated 2½ hr from the time on the New York Buenos Aires route

Lightplane shipments totaled 311 aircraft at a dollar value of $2,596,000 during June, dropping from the previous month's 388 units at $3,435,000, according to figures released by Aircraft Industries Assn.

Automatic ejection seats with telescoping rails that guide the seat out of a cockpit are being installed by Lockheed Aircraft Corp in F-94Cs The new device was developed by Lockheed, tested in flight at USAF's Wright Air Development Center

Civil Aeronautics Administration has approved a change in Hamilton Standard's automatic propeller feathering circuit that gives a two-second delay between cockpit indication and start of blade action, allowing the pilot an opportunity to reject reversal

John Floberg, former Assistant Secretary of the Navy for Air, has returned to the law firm of Kirkland, Fleming, Green, Martin, and Ellis as a resident Washington member Before entering Naval service in World War II, Floberg served with the firm at its Chicago headquarters.

Financial

Lockheed Aircraft Corp, Burbank, Calif, last week reported Super Constellation sales averaged one every 10 days during the first half of 1953, pushing the mid-year commercial backlog to a record $150 million.

United Air Lines made net earnings of $4,068,416 for the first six months of this year, compared with $3,782,565 for the same period of 1952 Operating revenues totaled $83,075,523, a 14% increase.

Northwest Orient Airlines made a net profit of $302,500 from operating revenues totaling $29,095,000 during the first half of 1953, compared with a net loss of $525 and revenues of $24,657,600 for the similar period of the previous year.

North American Aviation reports a June 30 backlog of $1,130,573,807 and net income after taxes for nine months ending that date of $7,990,000 Total sales and other income for the period $460,712,180

Temco Aircraft Corp, Dallas, reports net income of $906,342 for the first six months of this year, compared with $860,223 in the first half of 1952 Sales were $27,505,040, a 9.7% increase

Continental Air Lines net income climbed to $1,040,204 during the first half of 1953 from $88,940 for the same period of last year Operating revenues were $5,222,117, compared with $4,900,252.

Western Air Lines reports a net income of $356,567 for the first half of this year, dropping from $445,839 for the same period of 1952 Operating revenues were a record $10,876,332, cut into by purchase of a new DC-6B fleet, inauguration of a new route and training program.

International

Three Comet 1As last week began flight on Air France routes to the Near and Far East Carrier has ordered three Comet 3s, expects to begin operating 10 Super Constellations, 15 Vickers Viscounts and 12 Breguet Deux Ponts this year,

Royal Air Force has taken delivery of the first of several Prestwick Pioneer liaison planes on order,

Piper's First Production Apache

First flight photo of the initial production model Piper Apache twin-engine four place light transport. It embodies numerous refinements over the prototype which has been undergoing a year-and-a half of flight tests. Plane pictured is of all-metal construction, compared with metal and partially fabric-covered previous version. Its external lines have been smoothed out, particularly the nose, engine nacelles and around the cabin In production at Lock Haven, Pa., the Piper Apache is scheduled to sell below $25,000 Powerplants are two 150-hp. Lycomings Cruise speed is reported at more than 180 mph, one-engine service ceiling, fully loaded, in excess of 5,000 ft

Nonsked Battle Brews in Senate

Commerce committee chairman is expected to favor skeds; subcommittee member fights five-point plan.

A clash over Senate Commerce Subcommittee's approach to its review of the 1938 Civil Aeronautics Act and its administration points to a major battle on the nonsked issue on Capitol Hill before long

In his outline of topics to be covered, the subcommittee's chairman, Sen John Cooper, put down charges of Civil Aeronautics Board discrimination against nonscheduled airlines for airing before the group

▶ **Skeds' Position**—This brought a staunch defense of the scheduled airlines' position from Sen Edwin Johnson, subcommittee member

Johnson expressed the hope that the group "will not be used unwittingly as a vehicle to promote selfish interests (of nonskeds) rather than the public interest"

He took issue with Senate Small Business Committee's report (Aviation Week Aug 1, p 56) laying down a five-point program to keep alive a lusty nonsked industry and calling on the Cooper subcommittee to implement the program He called it "more propaganda than a calm appraisal of actual conditions .," adding that "such a course by us could jeopardize our great national air transportation system which is so vital to our national defense."

▶ **Decisive Factors**—As a special committee, the Senate small business group lacks the authority to act on legislation, a power the Cooper subcommittee does have.

The third Cooper subcommittee member, Sen Dwight Griswold, has given no indication of his position, which could be decisive in the three-man group

Another factor that may influence the outcome is the switch in chairmanship of the full committee Sen John Bricker has taken over the reins from recently deceased Sen Charles Tobey, who appointed the Cooper subcommittee and indicated sympathy for the nonskeds' case Although Bricker has not actively participated in aviation matters so far, he is expected to lean in favor of the scheduled airline industry's position

Meanwhile, Air Transport Assn.'s president, Vice Adm Emory Land, protested that if the Small Business Committee's program were ever adopted "we would have two scheduled airline systems in the U S, each operating under different sets of rules"

▶ **Subcommittee Approach**—Here are highlights of Cooper's outline of the approach of his subcommittee

- **Define the public's interest** in air transportation as it looks in 1953, obtaining the views of leading economists, political scientists and industry representatives
- **Determine how monopolistic** and competitive practices manifest themselves in the airline industry and how the public is affected
- **Consider the extent** to which the spirit and intent of the 1938 CAA act has been and is being 'energetically and creatively fostered" by CAB
- **Propose measures** for the future that will strengthen the air transportation system in the passenger and cargo fields of domestic and international operations.
- **Consider the fundamental issue** of the right of entry of new companies into the field
- **Consider airline profits** and subsidies and the level of passenger fares and freight rates

▶ **Critical Reply**—Johnson's reply, skeptical of the Cooper agenda, criticized nonskeds for their "relatively poor safety record," Civil Aeronautics Administration for its "shameful failure' to enforce nonsked safety standards, and prodded CAB to enforce regulations against regular operations by nonskeds.

"The recent slaughter of troops in nonsked accidents has shocked the nation," Johnson declared "So far this year the nonskeds have had, altogether, four fatal accidents and killed 122 passengers" Over the five years from 1948 to 1952, he said, "the nonskeds killed over seven times as many passengers per passenger mile as did our certificated domestic and international carriers, combined."

He urged that the subcommittee take action along these lines

- **CAB should** either put an end to all nonsked route-type operations or define new legal limitations for a type of operation that is economically feasible

'Havoc reigns because a small vocal part of the air transport industry is unregulated and submits to no economic restraint"

- **"The nonskeds' record** of continuous overloading of planes, inadequate maintenance, untrained and over-worked pilots and disregard of prudent dispatching procedures is well known to the CAA," whose present method of "spot" inspection is "entirely inadequate"

The imposition of civil penalties for serious violations are "a mere slap on the wrist."

- **Too many nonskeds** operate on "a shoestring" with "insecure financing"

"I cannot see how anyone can find these carriers 'fit, willing and able' to receive a governmental operating authority to transport military personnel The responsibility of the nonskeds to carry the public with the highest practical degree of care should not be overlooked by the subcommittee either"

EISENHOWER INSPECTS XB-52

President Dwight D Eisenhower recently got a firsthand impression of the new Boeing XB 52 eight-jet Stratofortress during a visit to Seattle with other top government officials. Chief test pilot A M (Tex) Johnston flew the big bomber on two highspeed low-altitude runs past the President's reviewing stand and made a sharp, climbing turn from 500 ft. to 10,000 ft. Johnston climaxed the air display by landing and opening the plane's drag chute The President and his party are seen walking beneath one of the plane's big external fuel tanks, shown for the first time in this photo From left to right: Edward C Wells, Boeing vice president engineering, William M Allen, Boeing president, President Eisenhower; U S Secretary of the Treasury William M Humphrey, and Secretary of the Air Force Harold E Talbott (See "More B 52s?", p 426.)

Stockholders Approve Tiger-Slick Merger

Merger of Flying Tiger Line and Slick Airways came a step nearer last week after a nearly unanimous vote of approval by stockholders of the two air cargo carriers.

Only hurdle still to be cleared is Civil Aeronautics Board approval.

CAB staff considers advisability of the merger a "close question" from a public policy standpoint, plans to state its position for or against the merger in a brief to the Board's trial examiner this month.

The examiner will make an independent recommendation shortly thereafter, and the full Board is expected to rule after hearing oral arguments this autumn.

Riddle Quits ATA's Military Traffic Group

Reorganized Riddle Airlines has switched its military traffic agency representation from Air Transport Assn. to Independent Military Air Transport Assn.

Riddle retained membership with ATA on normal association matters, however.

New management took over the scheduled airfreight line last month (Aviation Week Aug. 3, p. 18), and Paul Weesner bought 20% interest in the company. Weesner is maintaining a silent-investor position, however. He has no office in the company and is not a member of Riddle's new board of directors.

President William Boyd plans to boost scheduled airfreight service and generally operate military contract flights with equipment that otherwise would be idle.

The company has raised an estimated $300,000 in new funds to restore a normal working capital position, according to reports.

Ted Wells Leaves Beech Aircraft

Ted A. Wells, vice president and chief engineer of Beech Aircraft Corp. since its organization in 1932 and for several years a director of the company, resigned last week. Ralph Harmon, Beech's assistant chief engineer, who had been with the company since early in World War II, also resigned.

T. D. Neelands Jr., another Beech director, resigned late last month.

Wells and Neelands were among the oldest top brass in point of service at Beech. Both assisted the late Walter H. Beech in organizing the corporation.

Beech told Aviation Week no other changes are expected in the company management, that successors to Wells and Harmon will be announced later.

Officials reported employment at the Beech plant had dropped from a high of 13,500 last December to 7,500 early this month, following cancelation of the USAF T-36 program, in which Beech had a $100 million production contract.

ANDB Orders Civil Radar Beacon System

Air Navigation Development Board has launched a program to develop a new radar transponder beacon system for civil aircraft, a plan designed as a step toward a common navigation network for military and civilian flight.

The proposed 1,000-mc. system, predicted by Aviation Week (Mar. 30, p. 11), will be developed to work with the military system used to identify aircraft on terminal area radar scopes.

▶ **Tests in 1954**—First experimental units of the new system are expected to be tested early next year.

The beacons are small receiver/transmitters that reply to ground radars by transmitting a coded signal identifying the aircraft and providing a strong "echo."

▶ **Frequency Shift**—Previous ANDB radar beacons, which never got beyond the experimental stage, involved only an airborne unit triggered by radar energy from the ground-based air surveillance radars (operating at 3,000 mc.).

The new system involves not only a shift in frequency to 1,000 mc. but will require a special 1,000-mc. ground interrogator and receiver.

Navy's Bureaus of Ships and Aeronautics have been designated by ANDB to develop the ground-based and airborne portions of the new beacon system.

NAA TESTS SAPPHIRE-POWERED FURY

A prototype of the new North American FJ-3 Fury—an FJ-2 modified to take the Wright J65 Sapphire turbojet—recently completed its initial flight tests at Port Columbus, Ohio. First views of plane are shown. Described as heavier, slightly larger and faster than the earlier GE J47-powered FJ-2, the newer FJ-3 model is expected to have a top speed of approximately 700 mph. Most noticeable external difference over the FJ-2 is the revised nose intake for the larger Sapphire engine. Internal changes include an improved gunsight for its four 20-mm. cannon and new-type navigation equipment. The FJ-3 is in preliminary production stages at North American's Columbus, Ohio, plant. It is one of several Navy aircraft, including a new Grumman job, taking the J65.

EDDIE RICKENBACKER (seated left) discusses Eastern Air Lines affairs with the carrier's new president, Thomas F. Armstrong (seated right). Standing are Sidney L. Shannon, vice president-operations (left) and Paul H. Brattain, first vice president.

Eastern Names New President

Capt. Eddie Rickenbacker, president of Eastern Air Lines for the past 15 years, has turned that post over to Thomas F. Armstrong, EAL's former treasurer and secretary, in a surprise shift of the carrier's management.

Rickenbacker was elected chairman of the board and keeps his position as chief executive and general manager.

▶ **Jet Planning**—He said at a press conference he hoped the top-level switch and other changes would give him more time for policy matters and long-range planning.

Jet transports are coming inevitably, he said, and the "hard, realistic" thinking about them has to be done now. And "economic readjustments" are on the horizon—"We have to learn to sell and merchandise again."

▶ **Top Team**—Armstrong, who joined the company in 1928 as an apprentice bookkeeper, has been secretary and treasurer since 1938 and a director since 1940. Thomas E. Creighton, formerly assistant secretary, succeeds him as treasurer and becomes a member of the board. Floyd Farley, who was assistant treasurer, was elected secretary.

They will be part of a "top management" team of a dozen men, Rickenbacker said.

▶ **Guided Judgment**—Rickenbacker explained that one purpose of the changes was "to get young men on the job where they can carry the load and responsibility," but Eastern's "oldtimers" are staying on the job and the younger men will have "opportunity to exercise judgment but with guidance."

Armstrong is 51 years old, Creighton 40 and Farley 47. Rickenbacker said he would be 63 in October.

Towers Heads FSF

Adm. John H. Towers (USN Ret.), often described as the "principal architect of Naval aviation," has been elected president of Flight Safety Foundation, Inc., FSF managing director Jerome Lederer announced last week.

The admiral will take over organizational planning, finance and public relations, freeing Lederer to devote full time to the "promotion of ever greater safety in aviation."

The first Naval aviator to reach the rank of admiral, Towers was chief of the Bureau of Aeronautics in 1939, became commander of Naval and Marine forces in the Far East during the final part of World War II, and was chairman of Navy's now-defunct General Board shortly before his retirement in 1947. He is a former vice president of Pan American World Airways and presently is a PAA consultant.

Comet Ban

- **U. S. ambassador steps into RCAF-NATCC fight.**
- **Says New York should allow occasional landing.**

International diplomacy has entered the National Air Transport Coordinating Committee's current fight (Aviation Week July 20, p. 14) to prohibit Royal Canadian Air Force Comets from landing at New York's Idlewild International Airport and other commercial fields in the area.

R. Douglas Stuart, U. S. ambassador at Ottawa, has written C. R. Smith, chairman of NATCC's executive committee and American Airlines president, that he hopes the group "will find it possible to permit the Comet to land at commercial airports on an occasional and infrequent basis."

Stuart said the U. S. embassy at Ottawa will face difficulties "if it should become necessary for the RCAF to request a clearance into New York for the Comet on behalf of the Minister of National Defense or an official of equivalent rank."

"It would be embarrassing," he said, "if such a clearance were refused when the aircraft in question is flying on commercial routes in many areas of the world."

Miss E. Claire Wilson, U. S. embassy civil air attache, has discussed the Comet problem with the RCAF "on several occasions," the ambassador wrote, "and they have to date refrained from operations into La Guardia and Idlewild."

However, he added, "the RCAF Air Transport Command is naturally anxious to proceed as soon as possible with the program they have established for this aircraft."

The Comet dispute began early in June when Air Commodore R. C. Ripley, chief of RCAF's Air Transport Command, asked the Port of New York Authority for permission to operate the Comet into Idlewild Airport on an intermittent basis. At the same time, he asked and received Civil Aeronautics Administration approval to land a Comet at Washington National Airport.

Port of New York Authority, however, turned for guidance to NATCC, later informed Ripley it would prefer that he not operate into Idlewild but land at a military field.

Smith said the different noise characteristics of a multi-jet transport would provide "fresh ammunition" to groups trying to close the airports.

In view of PNYA's refusal, the

Canadian Comet was flown to Mitchel AFB on Long Island after a stop at Washington July 8 and returned to Ottawa the following day.

Purpose of the Canadian Comet flights to this country, according to Air Commodore Ripley, is in the interest of joint security of the North American continent and as a means of transporting Canadian chiefs of state and other personages to and from the U.S.

Chase Reorganization Deadline Is Aug. 31.

Deadline for acceptance of one of two alternate plans for reorganization of Chase Aircraft Corp. has been set for Aug. 31, informed sources reported last week.

The alternatives:

- **Kaiser Motor Corp.** will put $1,750,000 on deposit at Chase National Bank in New York to form a new corporation with Michael Stroukoff holding all the stock. In exchange, he will surrender his 51% control of Chase.

The new corporation will have all the rights to Chase designs, Chase research and development contracts, its leases at Mercer County, N. J., Airport, and the right to purchase at book value all equipment of the present Chase company. Kaiser, for its deposit, will receive all rights to the C-123 assault transport and the Chase name.

- **If the Kaiser deposit** is not made on or before Aug. 31, the second plan will be followed. This provides for a reorganization of the Chase board of directors, with Stroukoff getting five of the nine-member board so he has effective control of the operating policies.

Kaiser now holds 49% of the Chase stock. It is understood that a preliminary agreement, providing that one of the two reorganization plans will be followed, already has been signed by Stroukoff and Kaiser representatives. (Other details of the proposed transaction appeared in AVIATION WEEK Aug. 10, p. 19.)

Army Orders First Production Firebee

Los Angeles—U. S. Army has placed the first production order for Ryan Aeronautical Co.'s jet-powered target plane, the Firebee.

Official designation will be XM-21, the Los Angeles Ordnance District revealed last week in announcing the contract.

▶ **Fighter Performance**—The Army announcement said the highspeed Firebee will be used in training units in the anti-aircraft operation of the Skysweeper gun, the Nike and "other guided missiles."

The XM-21 will maneuver at varying speeds and altitudes over anti-aircraft installations to simulate invading enemy aircraft. Ryan claims performance of the target aircraft, powered by a Fairchild J44 jet engine, approaches that of the F-86 jet fighter.

Army will ground launch the XM-21 with the aid of Rato (rocket assist takeoff) unit and a launching track. Rato is jettisoned after takeoff of the pilotless target plane.

▶ **First Contract**—Although development contract for the Firebee was under the joint auspices of the Army, Navy and Air Force, the Army contract is the first to be announced for the target aircraft.

The Firebee, with sweptback wings and tail surfaces, is approximately 18 ft. long with a 12-ft. span. Weight is estimated at 1,800 lb. A two-stage parachute recovery system is designed to lower the aircraft without damage after each flight.

MIT Engineer Wins Aviation Week Award

Massachusetts Institute of Technology has announced award of the 1953-54 Aviation Week Fellowship in aeronautical engineering to Robert Roy Piper of Princeton, N. J.

The award, made annually since September 1950, carries a stipend of $1,800 and goes to a student enrolled for an advanced degree in MIT's department of aeronautical engineering. Funds are provided through Robert W. Martin, publisher of AVIATION WEEK.

Piper, who entered MIT in the fall of 1949, is a member of the honors group of aeronautical engineering students and the student chapter of the Institute of the Aeronautical Sciences.

CAB Crash Report Blames Controller

A double misunderstanding of radio messages—between a pilot and a Civil Aeronautics Administration traffic controller—contributed to the crash of a C-46 Apr. 3 near Selleck, Wash., the revised opinion of Civil Aeronautics Board investigators reveals.

Preliminary field reports to CAB officials in Washington previously placed the blame solely on the pilot (AVIATION WEEK Aug. 3, p. 52).

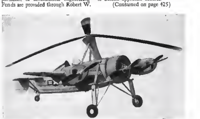
Two survived and two were killed when the American Air Transport plane hit a mountain range while approaching Seattle from Cheyenne.

Traffic control cleared the transport to cross the Hobart fan maker at 8,000 ft., then cross over to Seattle at or above 4,000 ft.

Tape recording of the subsequent radio transmissions:

- **Pilot:** "Roger, this, uh, nine three metro is cleared to, uh, Hobart—to—cross there four thousand or above—the range station, ah, four thousand we're to report to you at, uh, Hobart, over."
- **Controller:** "Negative, report Hobart to Seattle approach control."

(Continued on page 425)



AUTOGIRO MODIFIED FOR CONVERTIPLANE TESTS

Artist's conception of how tri-motor modification of prewar Kellett KD-1B will look. Craft is being rebuilt by the original maker under a Navy contract to gather convertiplane data (Aviation Week Aug. 10, p. 20). Two 140-hp. Lycomings and wings are to be added to the craft, also a new rotor power drive. Nose engine, a 225 hp. Jacobs, is being retained. Flight tests will check theories about unloading helicopter rotors and transferring loads to the wings. When completed the modified KD-1B will weigh approximately 3,400 lb. This Autogiro was used by Eastern Air Lines in 1939 on the first regularly scheduled rooftop rotary-wing airmail route between Camden (N. J.) Airport and the rooftop of Philadelphia post office.

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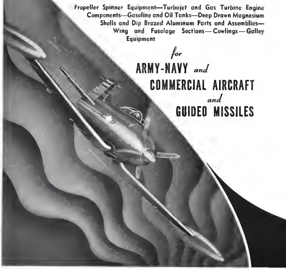

FACILITIES

ENGINEERING DEPT. equipped with complete library reproduction drawing equipment, and staffed with mechanical and technical engineers with extensive knowledge and thoroughly experienced with basic procedure in development and perfecting the complete product for its particular purpose

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MACHINE TOOL DIVISION equipped with engine and machine lathes, turret lathes, milling machines, boring mills, shapers, grinders, tapping machines power saws hardening furnaces, and radials drills

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MECHANICAL PRESS DEPT equipped with 15 punch presses ranging up to 100-ton capacity

SPINNING DEPT. equipped with electric annealing furnaces and 23 spinning machines with capacity up to 60 inches in diameter

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SHIPPING—Crate and box making department equipped with complete wood working equipment and large dock facilities for convenient loading and transportation

Benson MANUFACTURING CO.

NEW YORK KANSAS CITY LOS ANGELES

(Continued from page 420)

Thus, although the transcription reveals that the pilot said, "cleared to, uh, Hobart four thousand ," the controller said he heard only a three to four second pause in place of "Hobart" and therefore thought the query referred only to whom to report next

Static and outside noise, including four other radio receivers near the controller's ear, may have caused obliteration of words, according to testimony on this case by Carl F. Kusrow, district supervisor of the facilities operation branch of the CAA in Seattle.

Colonial Profit Cuts Need for Subsidy

Colonial Airlines last week revealed it has reduced its subsidy need to less than one-tenth of last year's requirement to break even after compensatory mail pay Colonial earned a \$375,000 net profit the first half of this year, compared with a \$200,000 loss a year ago.

Meanwhile, rivals Eastern and National Airlines await decision of the President on whether either or neither should be approved for purchase of Colonial (AVIATION WEEK Aug 10, p 55) Colonial's rapidly improving financial independence is taking some of the urgency out of the merger question

▶ **Subsidy Halved**—Colonial reported its subsidy need to break even dropped from \$816,000 the first half of last year to \$77,000 this year—after compensation for cost of hauling the mail. Overall subsidy, including profit element, was cut in half.

Colonial's net working capital, after purchase of a Douglas DC-4 for \$640,000 and other capital expenditures, was \$554,000 June 30, compared with \$918,000 a year ago.

June 30 capitalization was \$1,570,000 equity and no long term debt Net worth thus increased about \$380,000 from last year's equity of \$1 191 000.

▶ **Break Even**—Before receiving nonsubsidy compensation for carrying mail, Colonial reports break-even need of \$170 000 the first half of this year Compensatory mail rate would yield about \$93 000 This leaves non subsidy deficit of \$77 000. First half year usually is Colonial's poorer season. Second half business generally is better

▶ **Sales Gain**—Commercial revenues increased 51% the first half of this year—from \$2 658,000 a year ago to \$4 037,000 Bermuda traffic gained 63% and domestic passengers 45%.

▶ **Management**—New management policies include

- **Sales techniques,** including confirming reservations over scheduled capacity, then running extra sections to take the balance This includes the unorthodox procedure of sometimes running all planes at once, with no spares. Traffic vice president Robert Hernstein says the airline serves thousands more persons this way than by operating set schedules with spare planes standing by Plan seldom causes a flight cancelation, he says
- **Night** aircoach, designated "Owl" service, is patterned after Capital's original "Night Hawk" that blazed the coach trail for other scheduled airlines
- **Leasing Constellations** for the Bermuda run has improved Colonial's revenues and competitive position with Pan American and BOAC

Aviation's Women

Every week almost 135,000 women pocket an \$11-million slice of the U S aircraft manufacturing industries' payroll, says the Aircraft Industries Assn. Yet this is only a part of the economic role aviation plays in the lives of American women today An additional 20,000 women are working for America's scheduled airlines, another 18,000 are serving in aviation with USAF, Navy and Marines, 3,000 as flight nurses. Uncounted thousands more are employed by airport operators, federal aviation agencies, aircraft contractors and suppliers and air travel agencies

U. S. Forces ICAO Budget Cutback

(McGraw Hill World News)

Brighton, England—The seventh session of the International Civil Aviation Organization closed last month and the U S delegates could count at least two major objectives achieved

- **Budget** cut of almost \$300,000 was pushed through under strong U S. pressure. Most of the money was saved by permitting ICAO to draw on its financial reserves. The 60 member states will still contribute \$2 5 million this year, a little more than 25% coming from the U S
- **Limiting ICAO's activities** where they allegedly encroach upon the province of industry or operators (AVIATION WEEK June 29, p 67).

The conference also accepted Japan's application for membership, making ICAO the first United Nations agency on which this country is represented

▶ **Other News**—Other developments at the seventh session

- **Multilateral agreement** on commercial rights, a perennial target in the assembly, was stalled again this year by the U S on the grounds that codification of regional commercial rights of operators might work to the disadvantage of trunklines The assembly approved a request from the Council of Europe that a conference be convened by ICAO "to coordinate and improve European air transport"
- **Definition of nonsked rights,** also opposed by the U S, was defeated ICAO's Council was directed to study the problem, especially to see how charter operations could be distinguished from regular services U S held the view that it is too early to expect universal freedom for nonskeds
- **Factual report on charges** levied on operators for use of airports and radio facilities was ordered This report is to be forwarded to member governments to enable them reasonably to judge claims made by airport and aircraft operators
- **More emphasis on implementing** already accepted ICAO standards was called for in an assembly resolution An exception is the ICAO Airworthiness Standard, which is not binding on anyone

FAIREY ROTODYNE TRANSPORT

Artist's conception of the new Fairey Rotodyne convertiplane ordered by the Ministry of Supply to meet requirements of British European Airways for a large intercity coach type rotorcraft. Designed to carry 40-50 passengers, the Rotodyne will be powered by Napier Eland turboprops and have jet-driven four blade rotors

Spray Dusters Build Agriculture Plane

A new specialized agricultural airplane—capable of carrying more than 40 cu ft of spray, dust, seed or fertilizer—is under construction at Yakima (Wash) Municipal Airport The prototype is scheduled to make its first flight in October

Specifications for the new craft, named the Air Tractor, were laid down by Central Aircraft, Inc , of Yakima, one of the country's largest spray dust contractors Engineering was done by Lamson Aircraft Co , Seattle

In configuration, the Air Tractor is an equal-span twin bay staggered biplane Upper surfaces, of gull-wing design, taper sharply at the center section Upper and lower surfaces are fitted with end-plates Landing gear is conventional type with tail wheel Noteworthy features of the plane include

- **All wing panels** and all control surfaces are interchangeable
- **Rear of fuselage,** from behind the cockpit to the tail tip is uncovered to permit easy cleaning of the agricultural chemicals
- **Automotive parts** are used where possible.
- **No instrumentation** is inside the cockpit

The first Air Tractor is to be powered by a single 450 hp Pratt & Whitney Wasp Jr Lighter models, with 220-hp and 300 hp engines, are to be flown later

Central plans to sell the aircraft minus engines Customers will be able to send their own powerplants to the company for installation in a standard Air Tractor airframe

Ace Boosts F-86F

(McGraw Hill World News)

Tokyo—The North American F 86F Sabre is a far better fighting plane than the preceding A and E models and more than a match for Russia's MiG-15, USAF jet ace Maj James W Jabara told AVIATION WEEK prior to returning to the U S

Jabara said the F-86F has a higher ceiling than earlier Sabres, more speed and better pressurization, defrosting equipment and improved oxygen supply

Up to 40,000 ft , the new Sabre outperforms the MiG in every category but climb, where the MiG retains a slight edge The enemy jet also has a slightly higher operational ceiling, but this advantage has been cut by approximately 5,000 ft The more powerful General Electric J47 engine in the later Sabre permits it to overtake and outstrip the MiG, Jabara said

The triple jet ace also made these points

- **Radar gunsight** is indispensable for highspeed combat Improvements, especially those developed by Project Jaybird (AVIATION WEEK Mar 2, p 140), eliminated objections Jabara had towards the device at the end of his first tour of duty in 1951
- **Emergency systems** pay off and should not be eliminated

More B-52s?

Air Force officials are still musing over President Eisenhower's reported comment when he inspected Boeing's eight-jet B 52 while in Seattle for the Governors' Conference recently

The President turned to Boeing president William M Allen and said

"Well, I always see something new when I come here"

"New—and expensive," interjected Treasury Secretary George Humphrey.

"That's just like a Secretary of the Treasury," the President replied with a smile "George, order several hundred of them."

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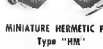

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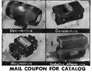

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